Aortic CTA vs MRA: which exam to perform?

Thomas M. Grist, MD
University of Wisconsin-Madison
Objectives

• List the advantages and limitations of MRA and CTA.
• Understand the diagnostic information available from each method.
• Discuss the role for each technique in evaluation of aortic vascular diseases
Outline

• Differences between CTA and MRA
  • Contraindications
  • Scanning
  • Diagnostic differences
    • Artifacts
    • Resolution
    • Function

• Cases
Contraindications - CTA

- Intravenous contrast
  - Prior anaphylactic reaction
  - Renal insufficiency
- Radiation exposure
  - Pregnant patients
  - Young adults and children
Radiation dose: Growing risk

- CT has revolutionized medicine since its invention in 1967
  - Main method of diagnosing many medical problems
  - Hounsfield and Cormack received Nobel Prize in 1979

- Increasing concern over radiation exposure from medical imaging

**Figure 2. Estimated Number of CT Scans Performed Annually in the United States.**
The most recent estimate of 62 million CT scans in 2006 is from an IMV CT Market Summary Report.

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Computed Tomography — An Increasing Source of Radiation Exposure

DJ Brenner and EJ Hall. NEJM 2007; 357: 2277-2284.

Estimating Risk of Cancer Associated With Radiation Exposure From 64-Slice Computed Tomography Coronary Angiography

# Radiation dose from CTA

<table>
<thead>
<tr>
<th>Examination</th>
<th>Typical Effective Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background radiation</td>
<td>3 (per year)</td>
</tr>
<tr>
<td>Chest x-ray</td>
<td>0.02 – 0.05</td>
</tr>
<tr>
<td>Chest CT</td>
<td>5 – 7</td>
</tr>
<tr>
<td><strong>Coronary CTA</strong></td>
<td><strong>5 – 20</strong></td>
</tr>
<tr>
<td><strong>Abdominal CTA</strong></td>
<td><strong>5 – 20</strong></td>
</tr>
<tr>
<td>Coronary cath (diagnostic)</td>
<td>2 – 6</td>
</tr>
</tbody>
</table>
Radiation dose: Cancer risk

DJ Brenner and EJ Hall. NEJM 2007; 357: 2277-2284.


Caveat: Based on the linear, no-threshold model
Radiation dose: Dose reduction

- Cancer risk is not constant and varies between men and women

- Implications for cardiovascular CT
  - In young patients
    - Consider imaging modalities that do not use ionizing radiation (MRI/MRA, ultrasound)
  - In older patients
    - Risk from CTA is less than for catheter angiography

- **Dose reduction techniques should be used when possible**

The *Image Gently* Campaign: Working Together to Change Practice

“Contraindications” – MRA

- Magnet
  - Pacemakers\(^1\)
  - Other implanted devices\(^1\)
  - Claustrophobia

- Gadolinium
  - Allergies *extremely* rare
  - Patients at risk of NSF
  - Pregnancy

\(^1\)MRI.safety.com
University of Wisconsin:

- Any patient with
  - eGFR ≤ 30 mL/min/1.73m²
- Inpatient with
  - eGFR ≤ 60 mL/min/1.73m² AND
  - Pro-inflammatory condition/event
    - Vascular injury
    - Surgery
    - Systemic infection

Non-contrast MRA
## Scanning differences

<table>
<thead>
<tr>
<th></th>
<th>CTA</th>
<th>MRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>Large FOV with single scan</td>
<td>Large FOV with multiple scans</td>
</tr>
<tr>
<td>Setup time</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Scan time</td>
<td>Short</td>
<td>Long(^1)</td>
</tr>
<tr>
<td>Technical complexity</td>
<td>Easy to perform</td>
<td>More difficult to perform</td>
</tr>
<tr>
<td>Postprocessing time</td>
<td>Long</td>
<td>Short</td>
</tr>
<tr>
<td>Claustrophobia</td>
<td>Rare</td>
<td>Occasionally</td>
</tr>
</tbody>
</table>

### Overall,

*CTA quicker and easier to perform.*

*MRA more complex, but with more information.*

\(^1\)Many more sequences and much more information acquired with MRA. Actual MRA sequences are short.
Artifacts

- Metal –
  - CT – beam hardening
  - MR – susceptibility

- Severity depends on type, size, location
- CAUTION when grading in-stent stenosis

![CTA and MRA images with annotations](image-url)
MRA: Stent Artifact

- Stainless steel a problem
- Nitinol generally OK
Artifacts

- **Metal** –
  - CT – beam hardening
  - MR – susceptibility

- **Severity depends on type, size, location**
  - **CAUTION** when grading in-stent stenosis

- **Calcifications**
  - CT – beam hardening overestimates stenosis
  - MR – calcifications not a problem
Resolution

- Spatial resolution
  - Ability to resolve adjacent objects
  - CTA: 0.7 x 0.7 x 1.0 mm³
  - MRA: 0.5 x 1.0 x 2.0 mm³

- Contrast resolution

CTA  
MRA  
DSA
Resolution

- Spatial resolution
  - Ability to resolve adjacent objects
  - CTAD: $0.7 \times 0.7 \times 1.0 \text{ mm}^3$
  - MRA: $0.5 \times 1.0 \times 2.0 \text{ mm}^3$

- Contrast resolution
  - Ability to detect lesion
  - More than spatial resolution
  - Also depends on difference in density/intensity between vessel and surrounding tissues

Diagnostic differences
Function

- CTA is static
  - Anatomical information only
    - No hemodynamic information

- MRA is dynamic
  - Anatomical and hemodynamic information
    - Phase contrast
    - Time resolved (TRICKS) MRA
Function: CTA vs. MRA

2 month old male with aortic coarctation

Phase-contrast MRA using VIPR
7 minute exam
Function: CTA vs MRA

Time resolved CE-MRA can be used to assess hemodynamics of vascular lesions

37 year-old female with pulmonary sequestration
Case 1

- 45 year-old male in MVC

Widened mediastinum – CTA to rule out traumatic aortic dissection
Case 1

- 45 year-old male in MVC
Traumatic aortic dissection

- Rapid diagnosis and high NPV required
  - CTA preferred
  - Performed at same time as other CT imaging
  - Sensitivity 100%\(^1\)
  - In absence of direct evidence of tear, likelihood of injury is 0%\(^2\)


\(^2\)M Sammer et al. AJR 2007; 189: 603-608.
Case 2

- 73 year-old male with chest pain radiating to back

Widened mediastinum – CTA to rule aortic dissection
Case 2

- 73 year-old male with chest pain radiating to back

Type A dissection
**Acute aortic syndrome: dissection**

- Rapid diagnosis and high NPV required
  - CTA preferred\(^1\)
    - Sensitivity 100% Specificity 98%
  - ECG-gating required to compensate for cardiac motion in ascending aorta
  - MRA for patients who cannot have CTA
    - Sensitivity 98% Specificity 98%

\(^1\) T Shiga et al. Arch Intern Med 2006; 166: 1350-1356. (Meta-analysis)
Acute aortic syndrome: dissection

Non-contrast MRA

  - Retrospective review of 29 studies.
  - Single-shot SSFP images had accuracy of 100%
Case 3

• 24 year-old female with hypertension

Bilateral tardus parvus waveforms indicating either bilateral renal artery stenosis or obstruction proximally – MRA to rule out RAS and aortic coarctation
Case 3

- 24 year-old female with hypertension
Congenital

- MRA preferred
  - No radiation exposure
  - Able to evaluate hemodynamics through abnormalities
  - Evaluation of congenital heart abnormalities, if present

Cases - Thoracic:
- Sequestration
- Coarctation
- Patent ductus arteriosus
Aortitis

- Circumferential wall thickening, aneurysm, stenosis
- MRA preferred
  - Greater soft tissue contrast increases sensitivity and specificity

Cases – Thoracic aorta
Case 4

- 92 year-old female in ED with abdominal pain

Mass in abdomen displacing bowel peripherally – CT to rule out mass
Case 4

- 92 year-old female in ED with abdominal pain

AAA Impending rupture

Thrombosed Right CIA
Abdominal aortic aneurysm: Dx

- Ultrasound – screening
  - U.S. Preventive Services Task Force recommends screening with ultrasound men 65-75 years old who have history of smoking

- CT angiography – acute AAA rupture, follow-up
  - Endovascular Rx planning

- MR angiography – follow-up
  - Size
  - Type (saccular, fusiform, mycotic)
  - Location (suprarenal, infrarenal)
  - Extent

- Digital subtraction angiography – endovascular treatment

Pre-operative planning for stent graft
Aneurysm Volume Measurement: CTA

- Non-contrast CTA
- If change in aneurysm size >2%, consider endoleak
- Then perform contrast CTA
- Bley et al, Radiology 2009
Aortic aneurysm

- Detect and measure aneurysm
  - CTA and MRA equivalent

- Detect and measure affect on AV
  - MRI with cine bSSFP and PC

  better than

- ECG-gated CTA
Aortic aneurysm: measurements

- CE-MRA, like DSA, shows lumen, not true wall-to-wall diameter
- Need to look at other sequences to get wall-to-wall measurement
Artery of Adamkiewicz

- diameter 0.6 mm
- supplied by intercostal/lumbar arteries
- origin highly variable

= Great Radiculomedullary Artery

Artery of Adamkiewicz

Albert Adamkiewicz 1850-1921
Thoracoabdominal Aortic Aneurysm Repair
- intercostal/lumbar arteries ligated
- injury artery of Adamkiewicz

spinal cord infarction
- 5-10% in centers of excellence\(^1\)

measures to avoid paralysis
- CSF drainage
- intraoperative hypothermia
- pharmacologic protection

TAA repair

Reducing Paralysis Risk During TAA Repair

Intercostal artery reimplantation\(^1,\ 2\)

paralysis decreased from
\[4.83\% \text{ to } 0.88\%\]

Challenges

Artery of Adamkiewicz
supplied by radiculomedullary arteries

tiny artery: 0.6 mm diameter

variable supply: 70 left : 30 right, T7-L2

large FoV

great anterior radiculomedullary vein

- similar appearance
- different location
- difficult to identify vein & artery
Technique

- 3T with spine coil
- 40 ml Multihance
- Sublingual Nitroglycerine
- High resolution Sagittal TRICKS acquisition

artery of Adamkiewicz

great anterior radiculomedullary vein
How To Choose???

• Depends on…
• Application
• Technology
• Availability
• Patient Population
• Contraindications
Specific Applications (the easy ones)

- Aortic dissection, acute vascular injury, acute ischemia
  - CTA
    - Rapid diagnosis

- Congenital
  - MRA
    - Avoids radiation and can evaluate hemodynamics

- Vasculitis
  - MRA
    - Better contrast resolution
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Specific Applications (our preference)

- Aneurysm
  - CTA or MRA
    - MRA avoids radiation and nephrotoxic contrast material

- Peripheral vascular disease
  - MRA preferred
    - Easier image post-processing
    - Calcified plaque not a problem with MRA

- Arteriovenous malformations
  - MRA preferred
    - Time resolved MRA