Peripheral Vascular Disease: Should it be CT or MRI Imaging?

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FNabiMD

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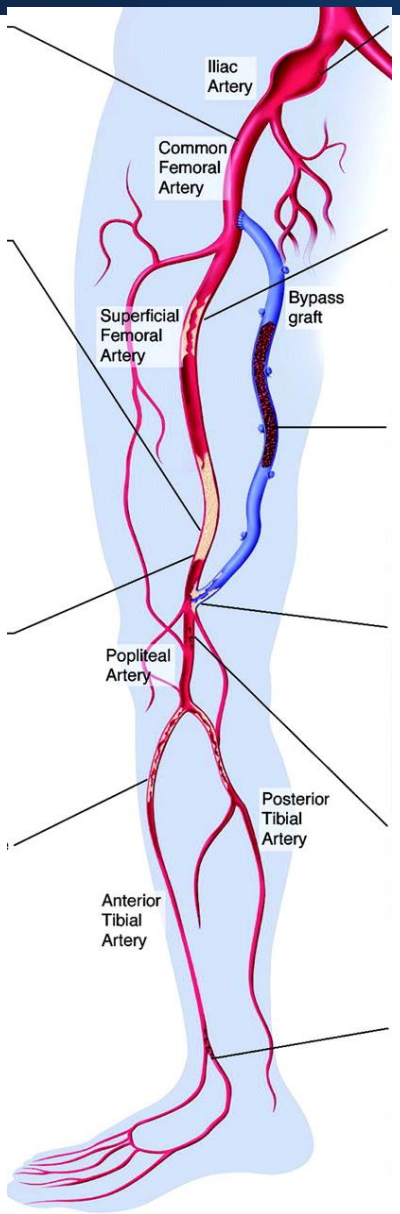
Peripheral Arterial Disease



- Affects over 8 million Americans
- Important marker for elevated risk of
  - CAD/MI
  - CVA
  - Death
- Symptomatic PAD adds to this burden by affecting quality of life and limiting functional capacity
  - Claudication
  - Acute/Critical limb ischemia

Rogers, J. H. et al. Circulation 2007;116:2072-2085

Clinical Diagnosis of PAD

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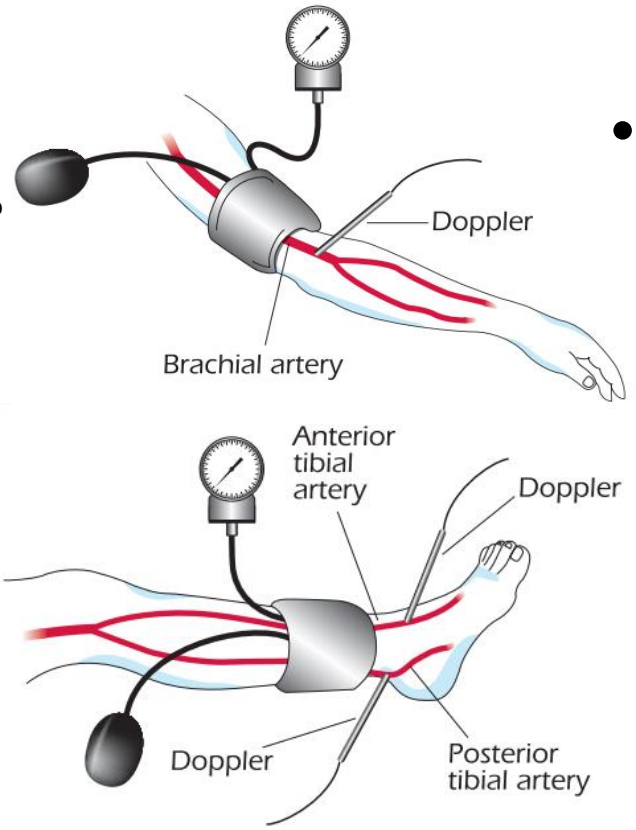
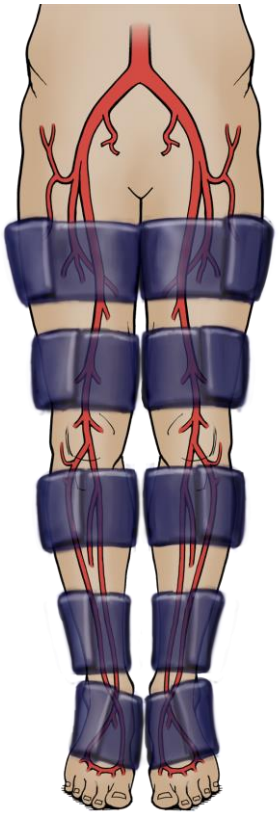
COR	LOE	Recommendations
I	B-NR	In patients with history or physical examination findings suggestive of PAD (Table 4), the resting ABI, with or without segmental pressures and waveforms, is recommended to establish the diagnosis.

2016 AHA/ACC Guideline on the Management of Pts With LE PAD



- Physiological tests: **ABI ± segmental pressures**
  - ABI < 0.9; sensitivity 79%, specificity 96% for PAD (stenosis >50%)
  - Location inferred >20mmHg decrease in segmental LE pressures



Diagnostic Testing for Suspected PAD

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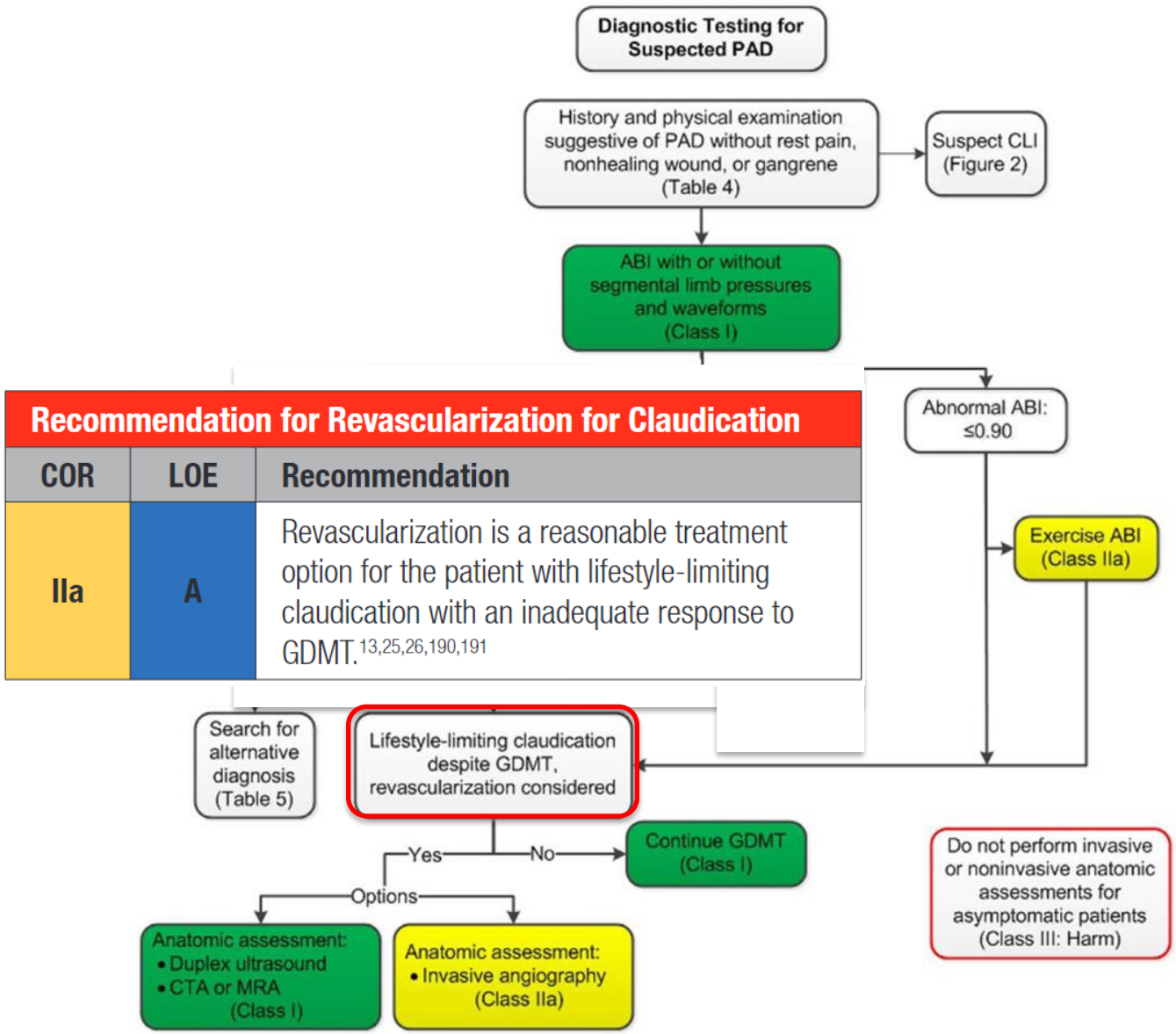
2016 AHA/ACC Guideline on the Management of Pts With Lower Extremity PAD



Recommendation for Revascularization for Claudication

COR	LOE	Recommendation
IIa	A	Revascularization is a reasonable treatment option for the patient with lifestyle-limiting claudication with an inadequate response to GDMT.[13,25,26,190,191]

Purpose of Imaging in Symptomatic PAD

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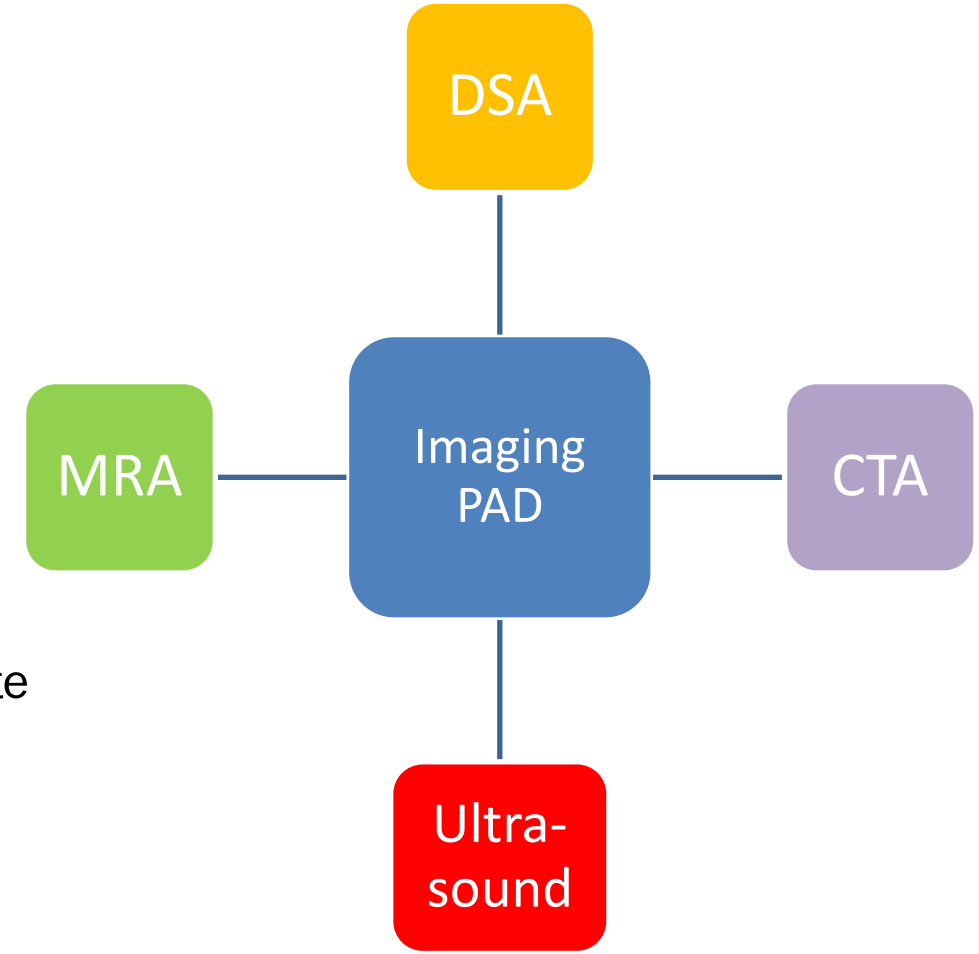
I	B-NR	Duplex ultrasound, CTA, or MRA of the lower extremities is useful to diagnose anatomic location and severity of stenosis for patients with symptomatic PAD in whom revascularization is considered.

- ***Anatomical* imaging :**
  - Confirm diagnosis if uncertain
  - Candidates for revascularization
    - Confirm the location and degree of stenosis
    - Provide details for complete endovascular/operative planning



Noninvasive Evaluation of PAD: Digital Subtraction Angiography

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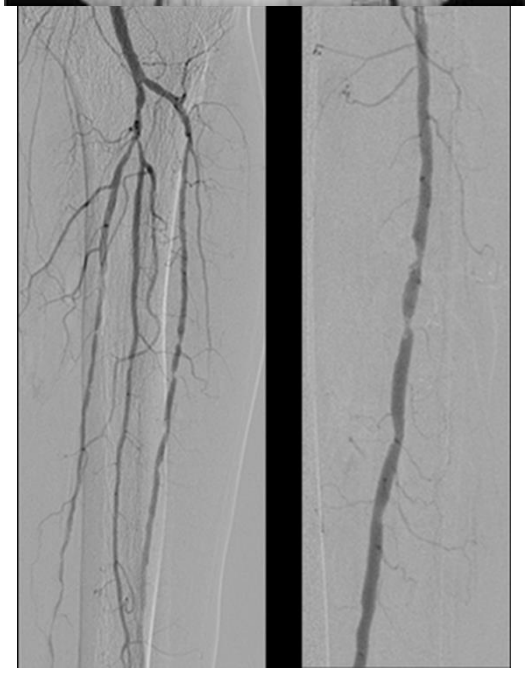
Gold Standard

- when revascularization planned -

I	C-EO	Invasive angiography is useful for patients with CLI in whom revascularization is considered.

- Limitations:
  - 2-D views only
  - Underestimates stenosis severity due to eccentric lesions
  - Unable to visualize vessel wall
  - Risks:
    - Invasive (arterial access)
    - Iodinated contrast media
    - Ionizing radiation



Noninvasive Evaluation of PAD: Duplex Ultrasound

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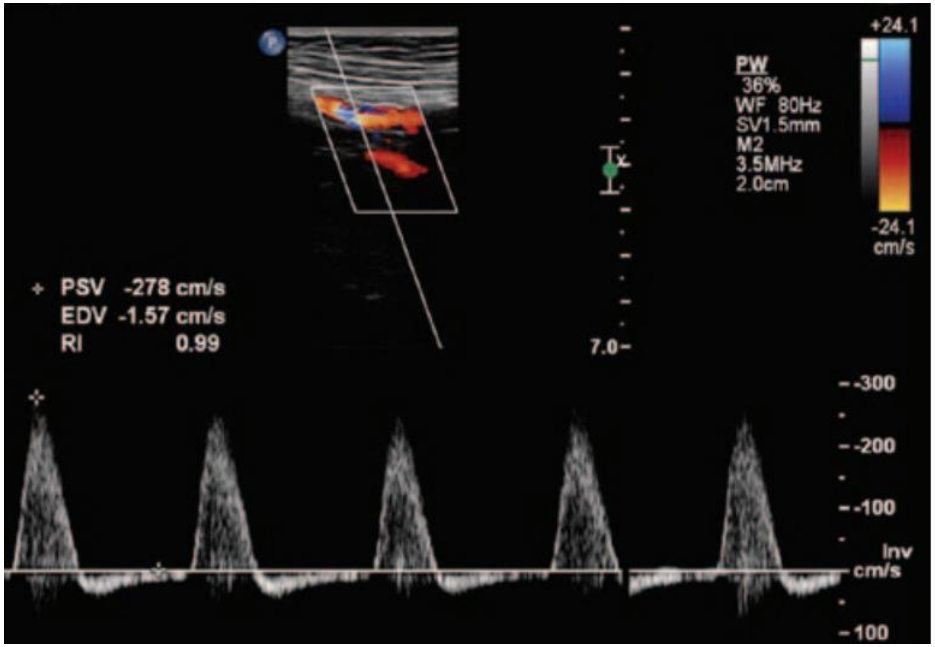
Advantages

- Widely accessible, inexpensive
- Anatomic & hemodynamic information
- Sens. and spec. for stenosis >50% is 88% and 96%



Disadvantages

- Body habitus may limit accuracy at adductor canal and the aorto-iliac region.
- Infra-popliteal vessels are time consuming and technically challenging
- Limited sensitivity for multilevel stenosis
- Dense calcium can limit
- Incomplete anatomic information for therapeutic decision making or planning interventions

Noninvasive Angiography – CTA / MRA
Advanced Post Processing Techniques

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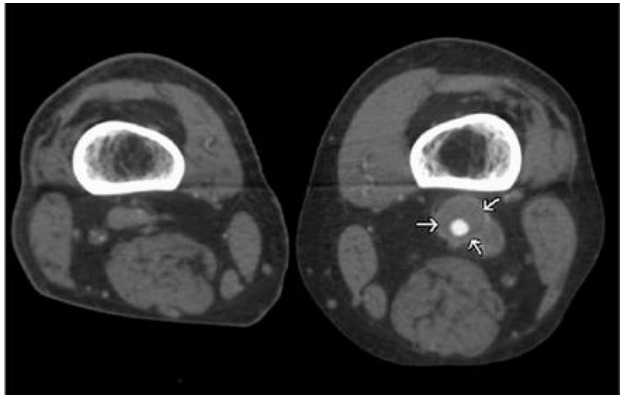
Axial 2D



- 3D image acquisition
- High spatial resolution
- Large field of view (FOV)
- Image interpretation with advanced post-processing techniques
- Excellent for planning revascularization strategies

Volume rendered

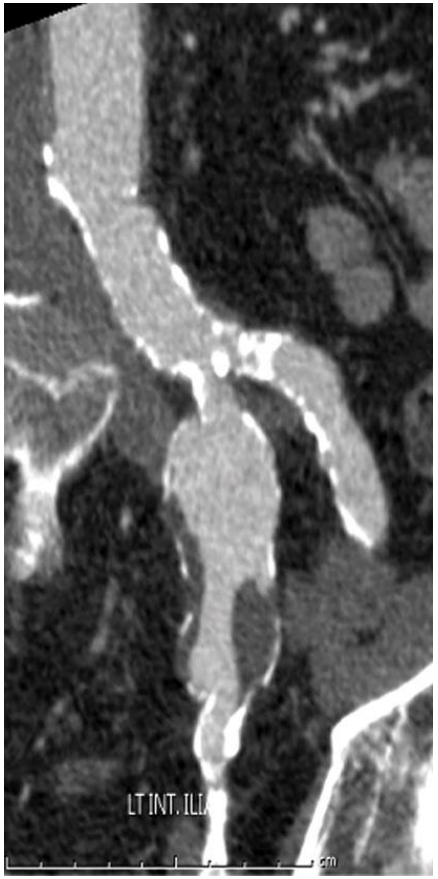
Global overview

MIP

Angio-like

MPR

Longitudinal and cross section views



Owen A R. Postgrad Med J. 2011 Mar;87(1025):189-98

General Imaging Considerations for Evaluating Symptomatic PAD

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Factors to Consider:

1. Diagnostic Accuracy
2. Strengths & Limitations of Each Modality
3. Risks / Contraindications for the Technique
4. Patient Characteristics

Noninvasive Angiography – CTA

Diagnostic Accuracy CTA for >50% Stenosis

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Meta-analysis: 20 studies; 957 pts
Standard = DSA; 68% PAD

Source, by Vessels	No. of Segments				%	
	True Positive	False Negative	False Positive	True Negative	Sensitivity	Specificity
Aortoiliac arteries						
Mesurolle et al,[27] 2004	18	0	1	29	100	97
Portugaller et al,[30] 2004	24	2	12	212	92	95
Willmann et al,[33] 2005[b]	75	3	6	267	96	98
Laswed et al,[4] 2008	20	1	0	139	95	100
Schernthaner et al,[5] 2008	58	3	4	157	95	98
Summary estimates (95% CI)					96 (91-99)	98 (95-99)
Femoropopliteal arteries						
Mesurolle et al,[27] 2004	31	1	4	55	97	93
Portugaller et al,[30] 2004	62	1	11	26	98	70
Willmann et al,[33] 2005[b]	98	3	10	201	97	95
Laswed et al,[4] 2008	53	4	5	106	93	95
Schernthaner et al,[5] 2008	221	3	2	364	99	99
Summary estimates (95% CI)					97 (95-99)	94 (85-99)
Tibial arteries						
Mesurolle et al,[27] 2004	3	4	3	19	43	86
Portugaller et al,[30] 2004	154	18	57	161	90	74
Schertler et al,[32] 2005	38	2	18	105	95	85
Willmann et al,[33] 2005[b]	177	7	22	496	96	96
Laswed et al,[4] 2008	238	6	15	161	98	91
Schernthaner et al,[5] 2008	200	0	2	337	100	99
Summary estimates (95% CI)					95 (85-99)	91 (79-97)
Femoropopliteal-tibial arteries						
Li et al,[24] 2008	110	2	4	100	98	96

Met. JAMA. 2009;301(4):415-424

Noninvasive Angiography – MRA

Diagnostic Accuracy MRA for >50% Stenosis

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AORTO-ILIAC

20 studies;
1022 pts

Author	n	Sensitivity	Specificity
Snidow	30	100	94
Quinn	30	100	98
Ho	28	89	98
Hany	37	97	96
Poon	15	100	100
Sueyoshi	23	100	96
winterer	76	100	98
Lenhart	17	93	85
Lundun	39	83	92
Sueyoshi	13	88	100
Weighted Average	308	95.6%	95.9%

FEMORO-POPLITEAL

Author	n	Sensitivity	Specificity
Ho	28	91	98
Sueyoshi	23	100	99
Winterer	76	100	98
Lenhart	17	98	98
Weighted Average	144	98.0%	98.2%

TIBIAL

Author	n	Sensitivity	Specificity
Glickerkman	23	86	91
Snidow	42	92	91
McDermott	24	89	91
Cartell	31	98	95
Ekiof	24	81	94
Weighted Average	120	91.8%	92.0%

Menke. *Ann Intern Med*. 2010;153:325–334

Non-invasive Diagnosis of Symptomatic Carotid Stenosis

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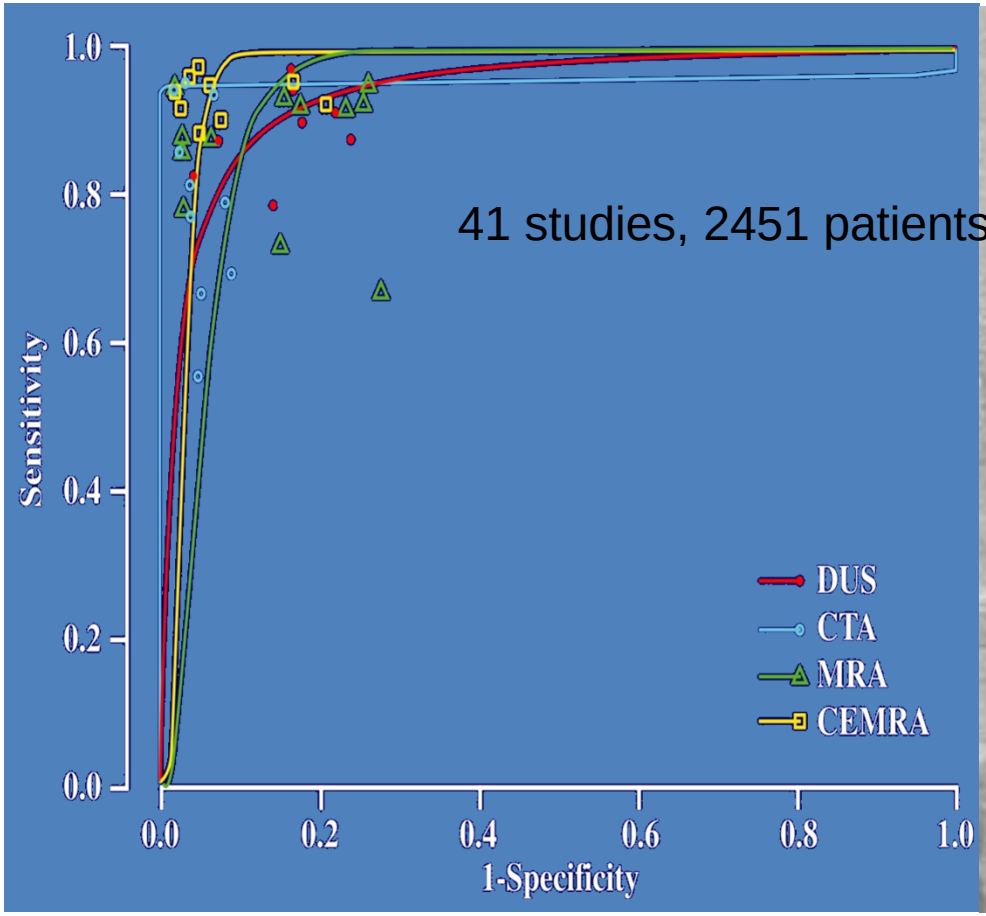
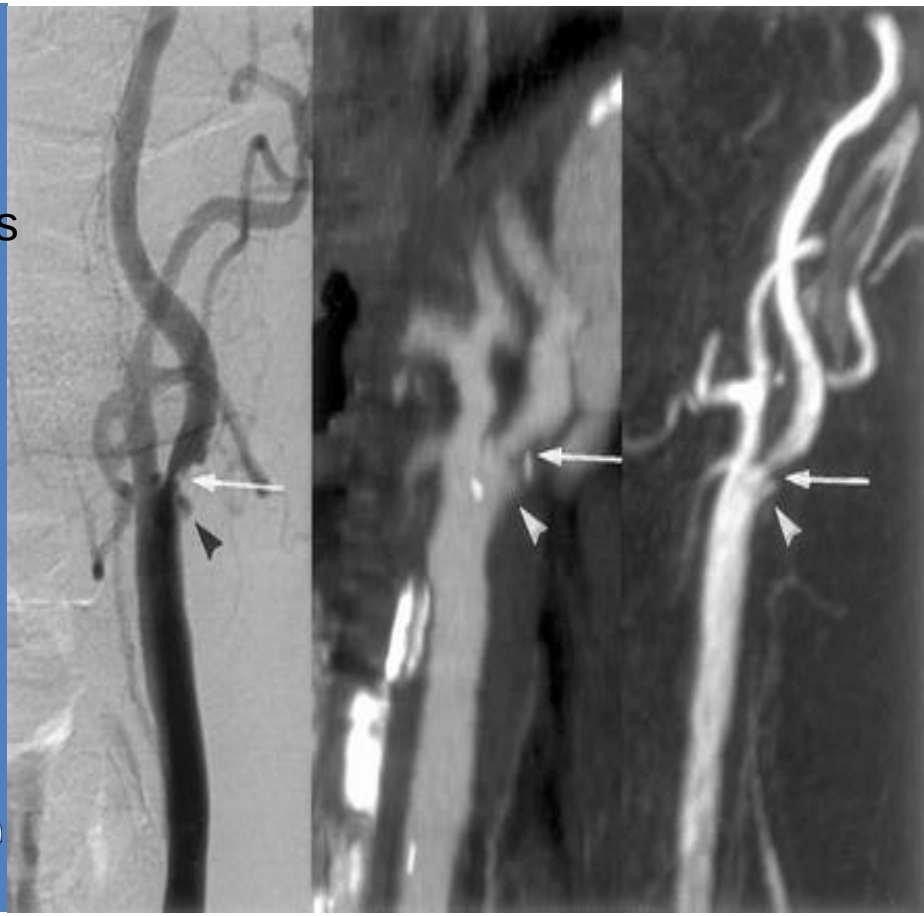
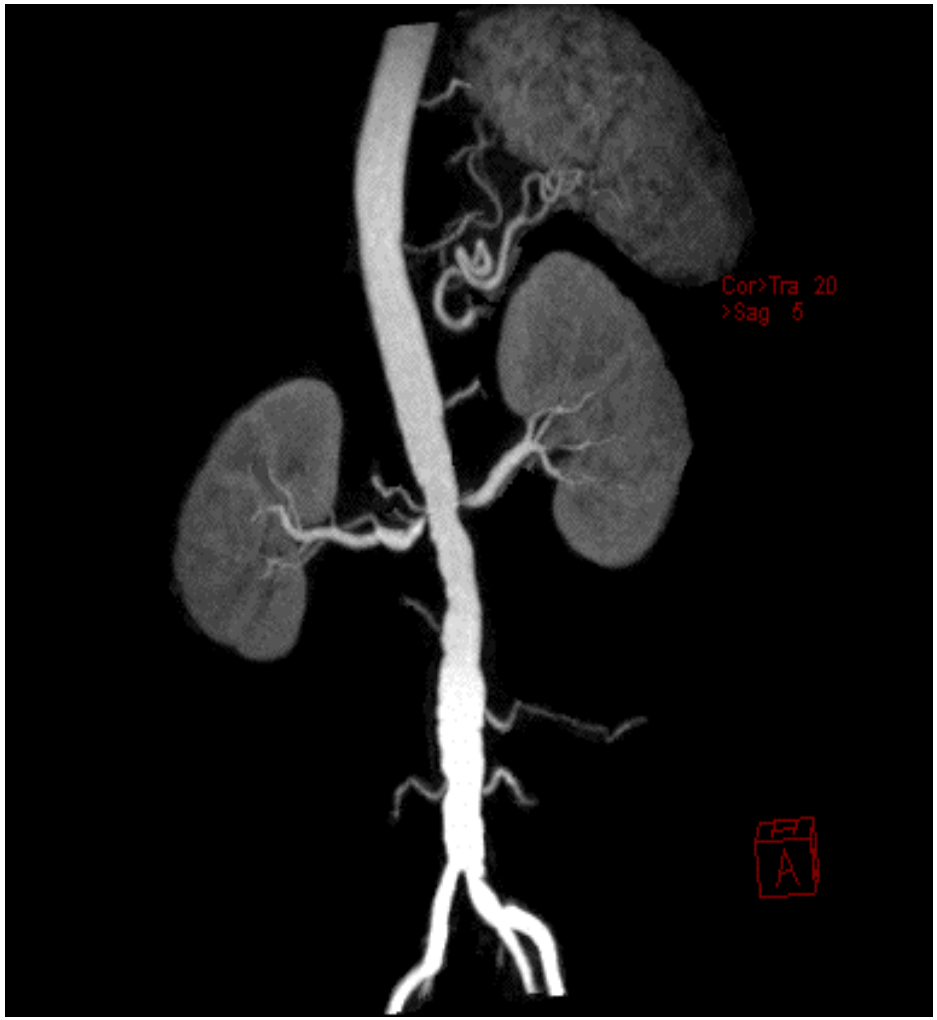




NO risk of *stroke* with non-invasive techniques

Lancet 2006; 367: 1503-1512

Diagnosis of Renal Artery Stenosis: MRA



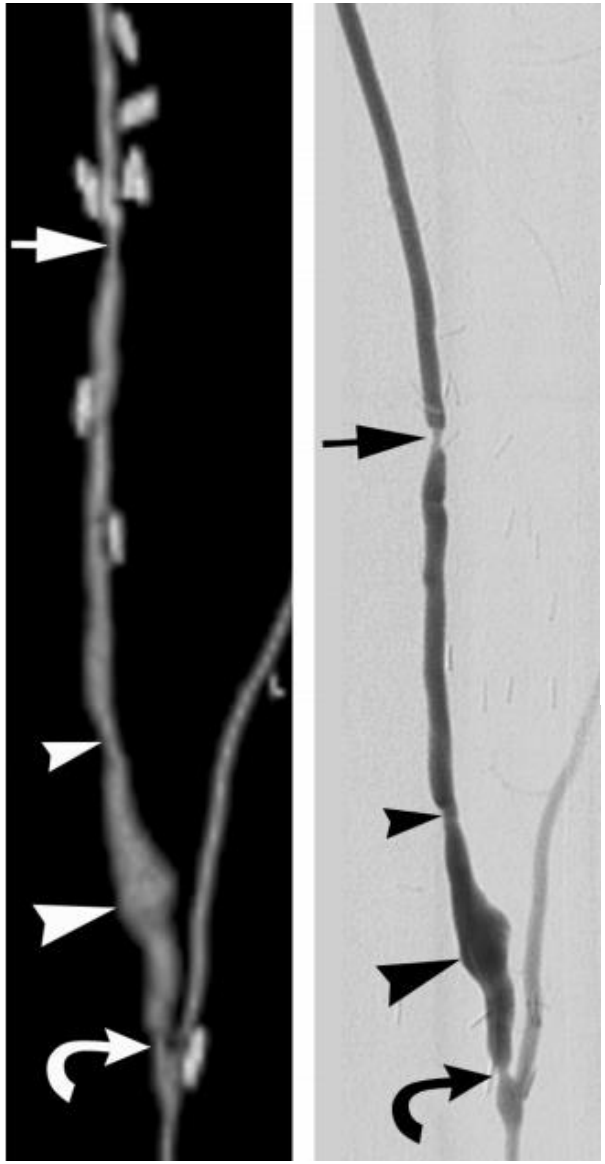
3-D Gadolinium enhanced MRA

Study	N	Sensitivity	Specificity
Kaufman et al	27	89	98
Holland et al	63	100	100
Snidow et al	82	100	100
Hany et al	39	93	98
Rieumont et al	30	100	71
Steffens et al	50	98	96
Total Weighted Average	**291**	**98%**	**96%**

Information Provided:

- Renal artery stenosis
- Accessory arteries
- Blood flow

Evaluation of Peripheral Arterial Bypass Grafts



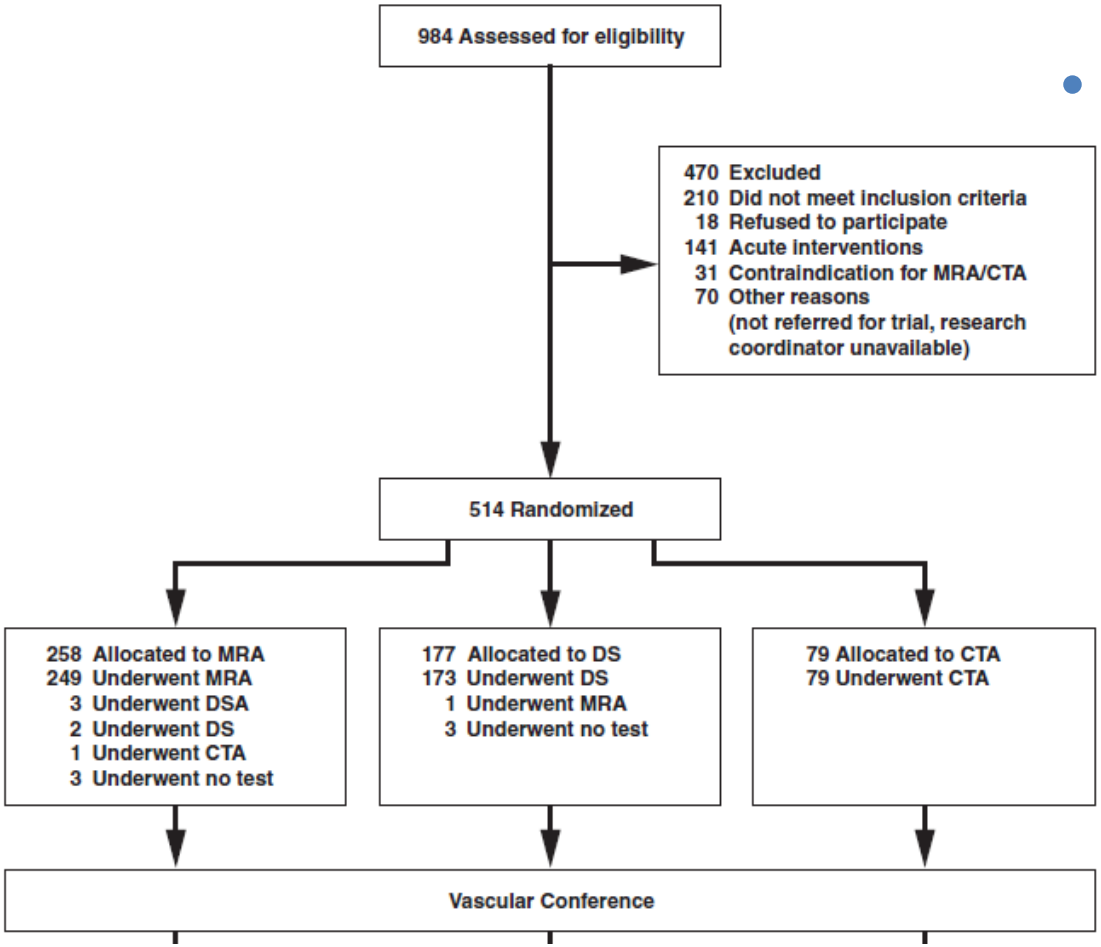
27 pts with DSA, US, CT
99 Arterial Bypass Graft Segments

Finding in Arterial Bypass Graft	Sensitivity (%)			Specificity (%)		
		Multi–Detector Row CT Angiography			Multi–Detector Row CT Angiography	
	Duplex US	Reader 1	Reader 2	Duplex US	Reader 1	Reader 2
Stenosis*	100 (98,100)	100 (98,100)	97 (88,100)	96 (90,100)	100 (99,100)	100 (99,100)
Aneurysmal change	67 (0,100)	100 (83,100)	100 (83,100)	100 (99,100)	100 (99,100)	100 (99,100)
Arteriovenous fistula	100 (50,100)	100 (50,100)	100 (50,100)	98 (95,100)	98 (95,100)	99 (96,100)

Willman JK. Radiology. 2003 Nov;229(2):465-74.

DIPAD Trial

514 PAD pts randomized MRA/CT or US



- MRA / CTA vs. US:
  - Higher confidence in making a therapeutic choice
  - Less additional vascular imaging ordered
  - Cost savings

Ouwendijk R. Radiology. 2005 Sep;236(3):1094-103

General Imaging Considerations for Evaluating Symptomatic PAD

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Factors to Consider:

1. Diagnostic Accuracy
2. Strengths & Limitations of Each Modality
3. Risks / Contraindications for the Technique
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CTA for PAD: Strengths

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- MDCT scanners readily available
- Rapid acquisition (<5 min)
  - Faster than MRA
- Large FOV
- High, isotropic spatial resolution (~0.5mm)
  - Optimized visualization of smaller, distal arteries

CTA for PAD: Strengths

In-stent Restenosis Evaluation of Metallic Stents

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Normal stent

Severe in-stent restenosis

Assessable stents	Total in-stent restenosis	Assessable in-stent restenosis
Sensitivity	24/28(85.7%)	21/22(95.4%)
Specificity	53/53(100%)	53/53(100%)
PPV	24/24(100%)	21/21(100%)
NPV	53/57(93.0%)	53/54(95.1%)
PA	95.1%	98.7%

Beam hardening artifact from small stents can be limiting

Li. *Eur J Radiol*. 2010;75:98–103

CTA for PAD: *Limitations*

- Heavily Calcified Vessels -

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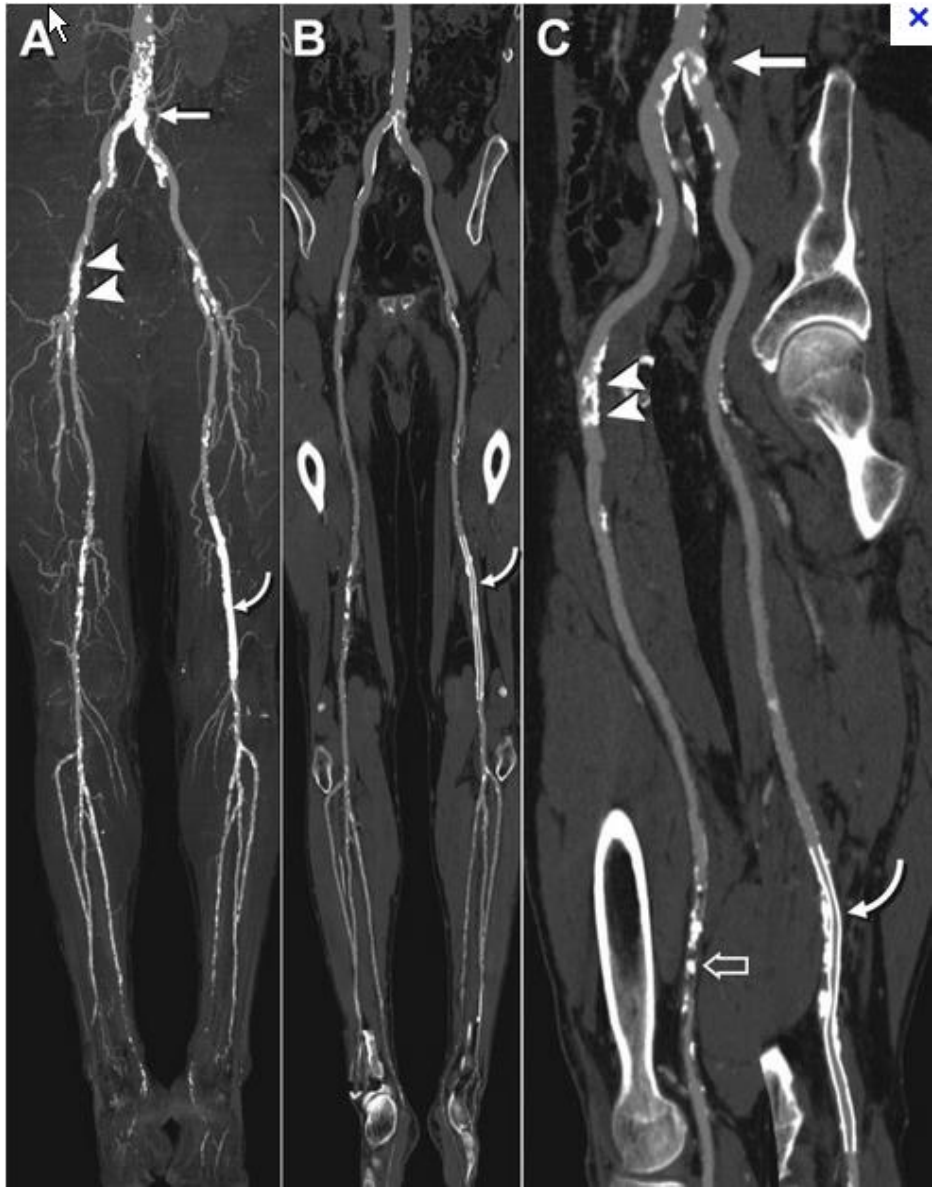
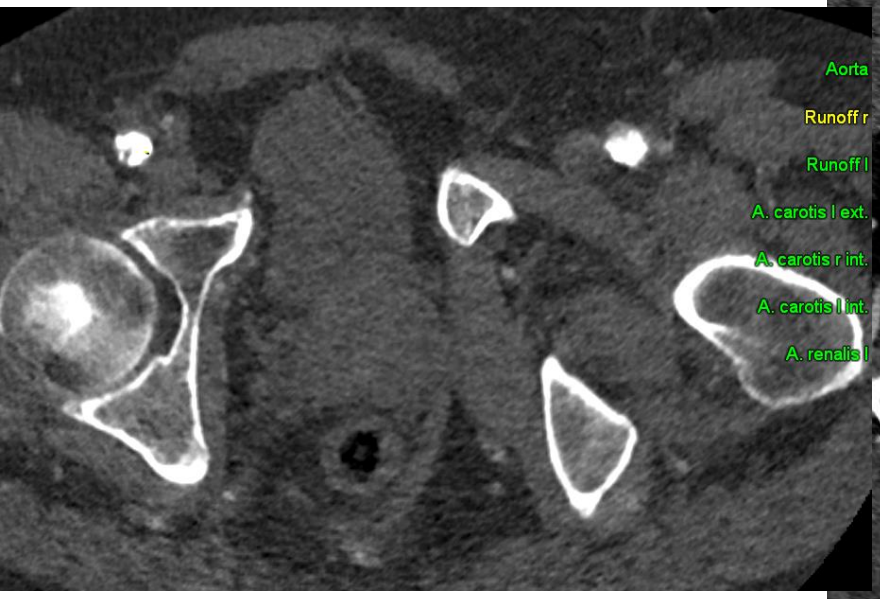
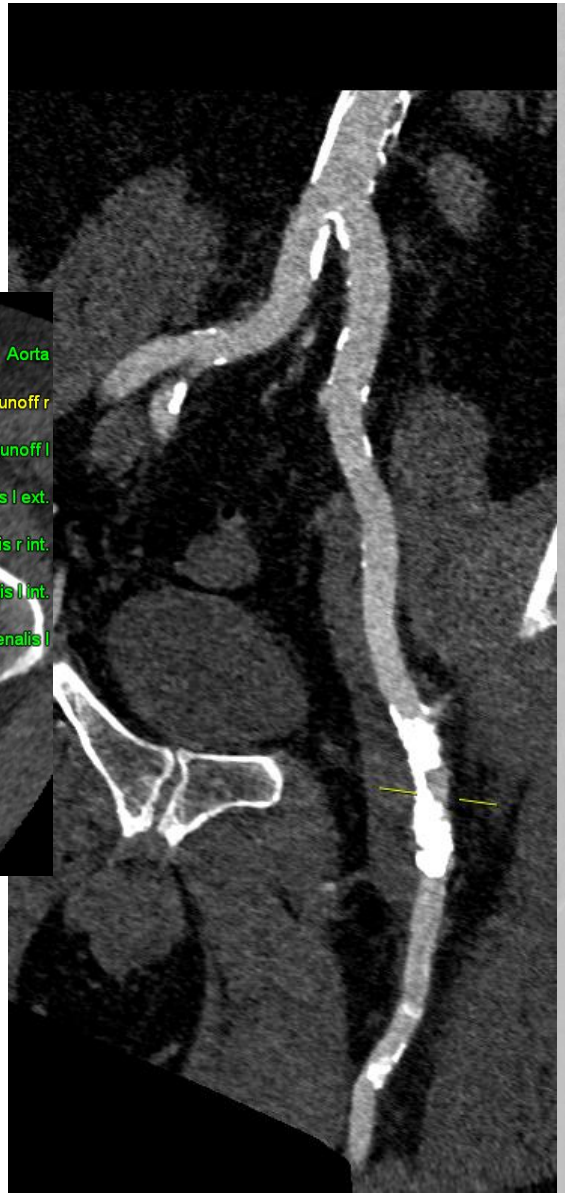
- Dense calcified plaques cause “blooming” obscuring the lumen
  - Leads to stenosis overestimation & false positive results.
  - Often prevalent in elderly, diabetics, & renal patients

➢ Solutions:

- Thinner slices (0.5–0.6 mm)
- Sharper filters or kernels
- Dual energy CT (DECT)







Occluded bilateral femoral arteries

CTA for PAD: *Limitations*

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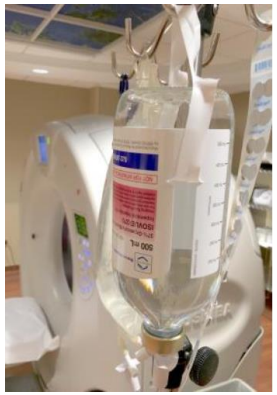
- Iodinated contrast media (100-120ml; 4-6 ml/sec)
  - Contrast induced Nephropathy
    - CRI, DM, CHF
  - Contrast allergy



- Ionizing radiation exposure
  - Cumulative radiation doses with repeat studies
  - Young
  - Pregnancy

➢Solutions: New generation MDCT scanners

MRA for PAD: Strengths

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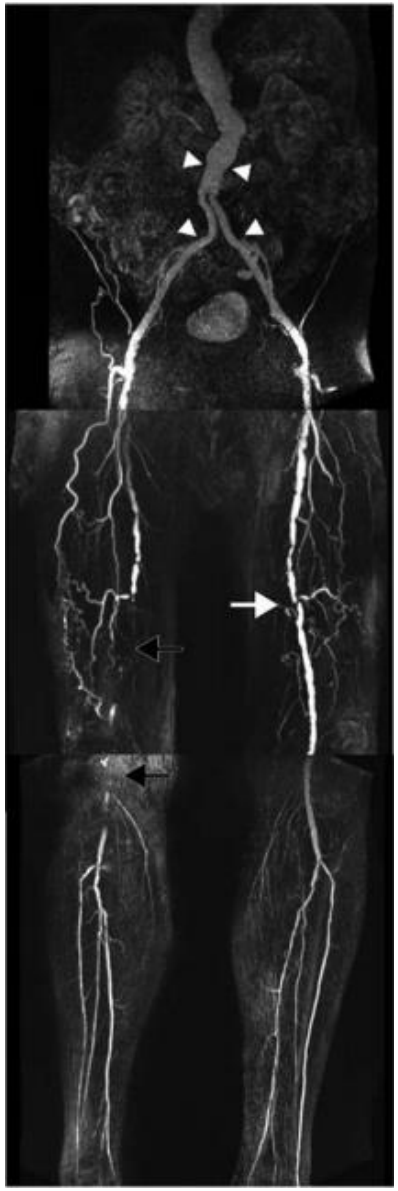
- NO radiation
- NO iodinated contrast
- 3D data set with high SNR
- 2 techniques:
  - Contrast (Gadolinium) enhanced
  - Non-contrast enhanced (TOF, FSE, FFSP)

    [diagnostic performance CE-MRA > TOF]
- Dynamic imaging with high temporal resolution (~50ms)
- Hemodynamics (PC-CMR)
  - Flow quantification (velocity, pressure gradients, blood flow)
  - Organ perfusion imaging



Pollack. Circ Cardiovasc Imaging. 2012;5:797-807

MRA for PAD: Strengths
No Limitations from Calcium / Bone

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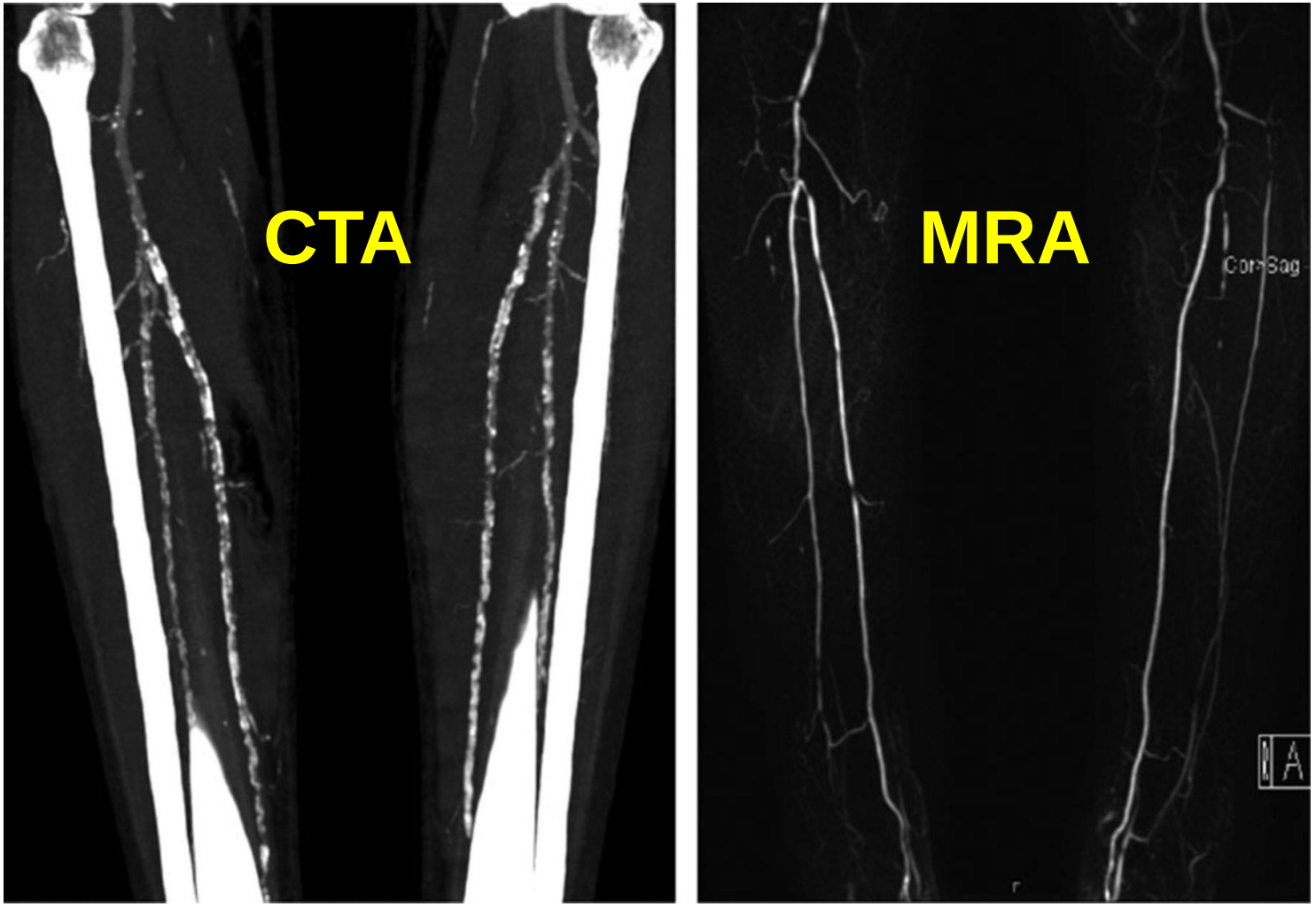
Diabetics frequently have heavily calcified vessels



Pollak A W et al. Circ Cardiovasc Imaging. 2012;5:797-807

MRA for PAD: Strengths
Non-Contrast Enhanced Techniques

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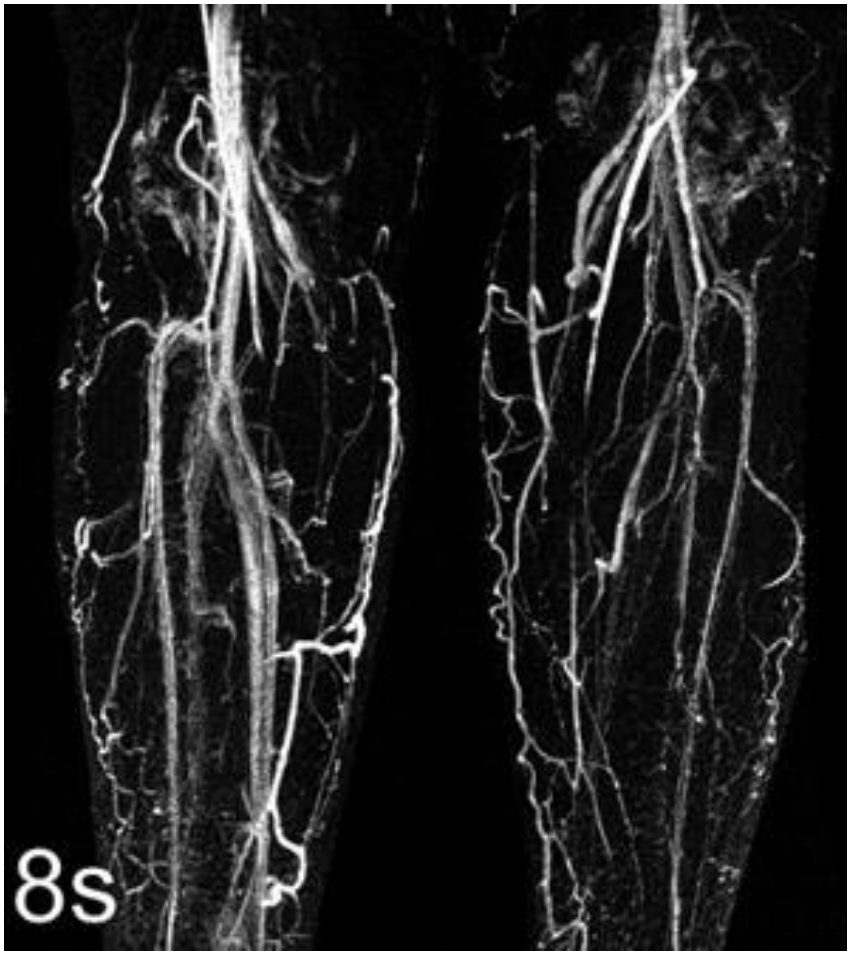
Flow-related enhancement methods

CE-MRA with venous contamination of tibial station in CLI



Non contrast MRA: Time of Flight (TOF)

Quiescent-interval single-shot (QISS): Non-contrast MRA Technique

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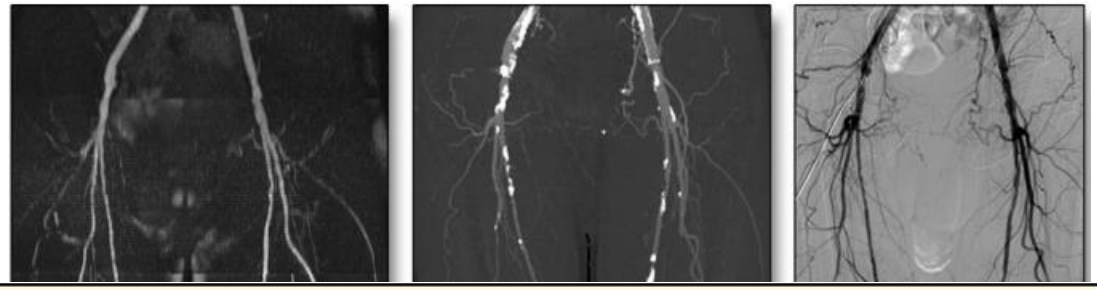
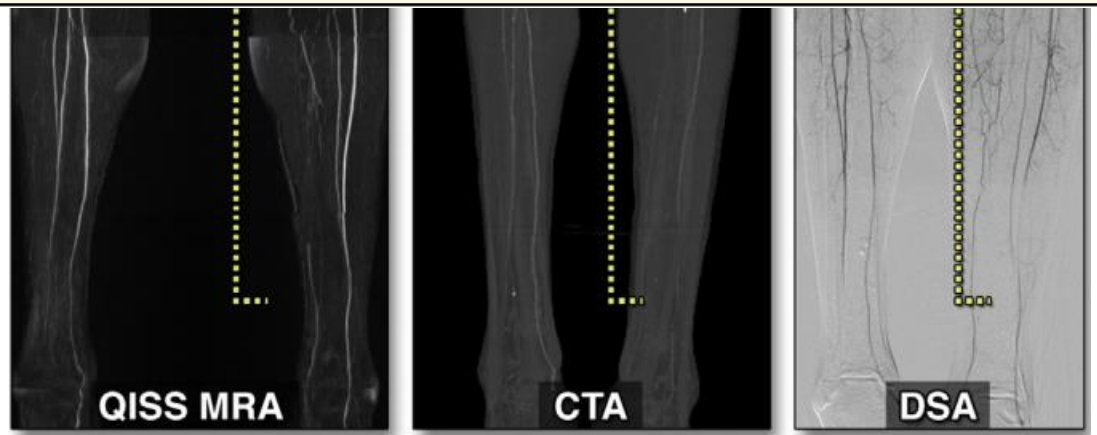
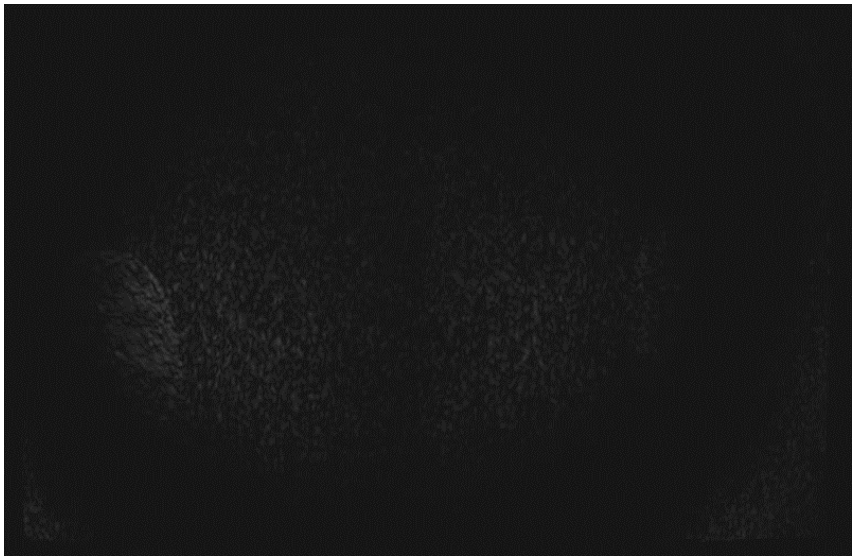


TABLE 3 Per-Segment Test Characteristics of QISS-MRA and CTA for the Detection of Hemodynamically Significant (>50%) Stenosis in the Lower Extremity Arteries Compared With DSA

	Sensitivity (%)	95% CI	Specificity (%)	95% CI
QISS-MRA	84.9 (107/126)	77.5–90.7	97.2 (276/284)	94.5–98.8
CTA	87.3 (110/126)	80.2–92.6	95.4 (271/284)	92.3–97.5



Varga-Szemes. J Am Coll Cardiol Img 2017;10:1116–24



MRA for PAD: Strengths

Dynamic / Functional Imaging

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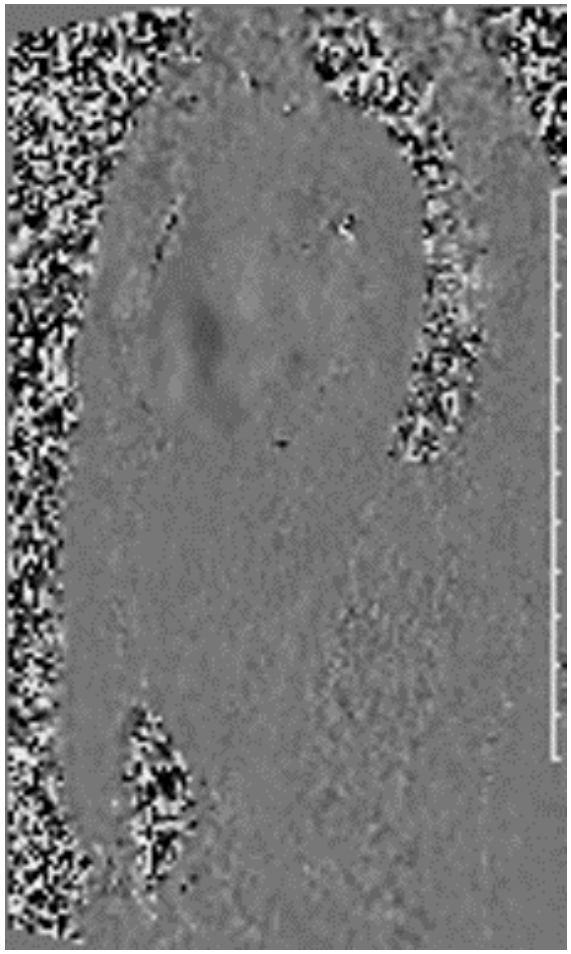
Cine SSFP:

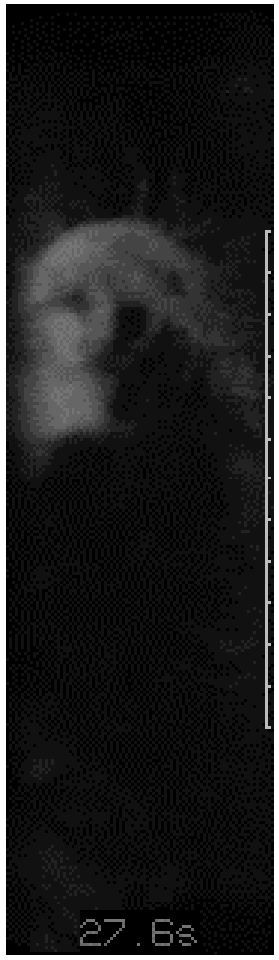
Dissection Mobility

PC CMR:

Flow



Time Resolved MRA



MRA for PAD: Strengths

Dynamic / Functional Imaging

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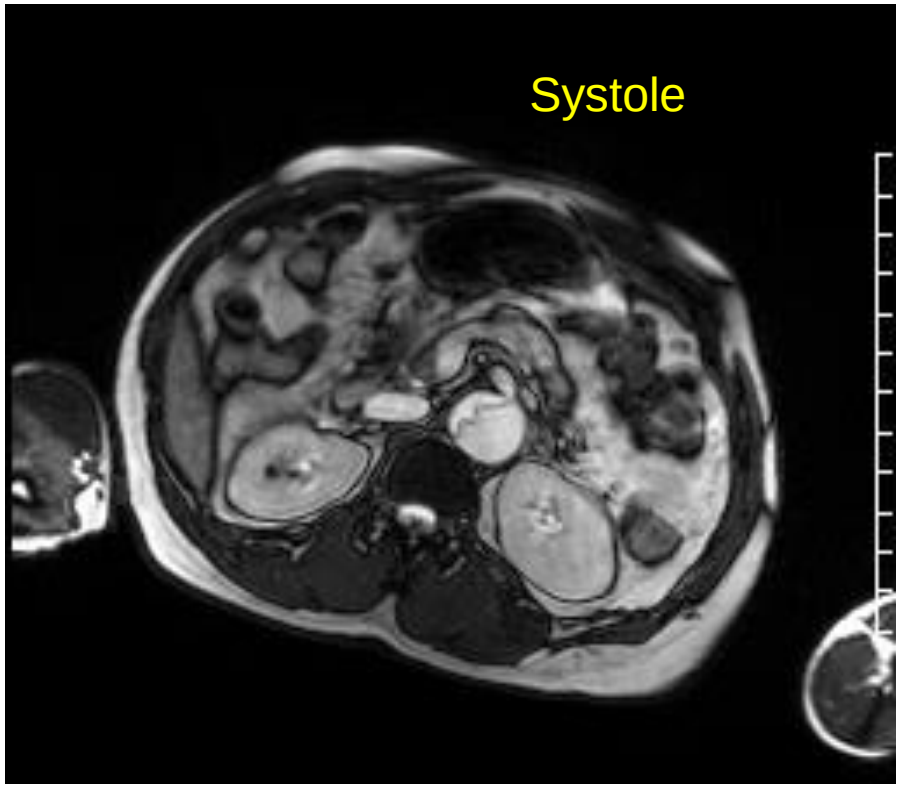
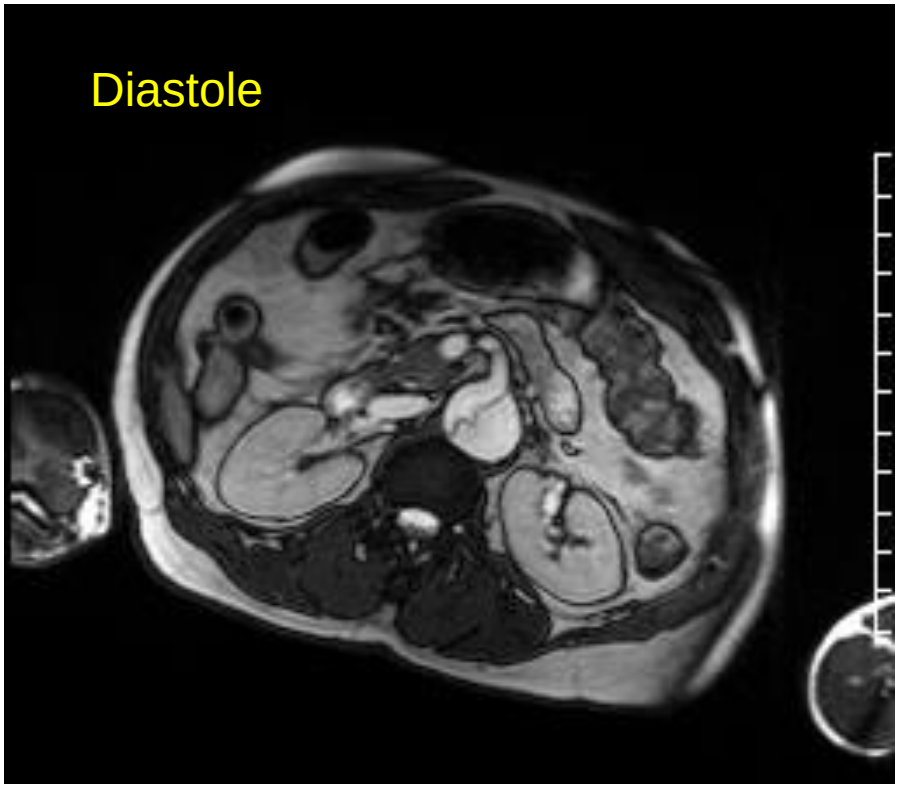
Dynamic Obstruction of Celiac Artery





MRA for PAD: *Limitations*

Limited Assessment of Stents

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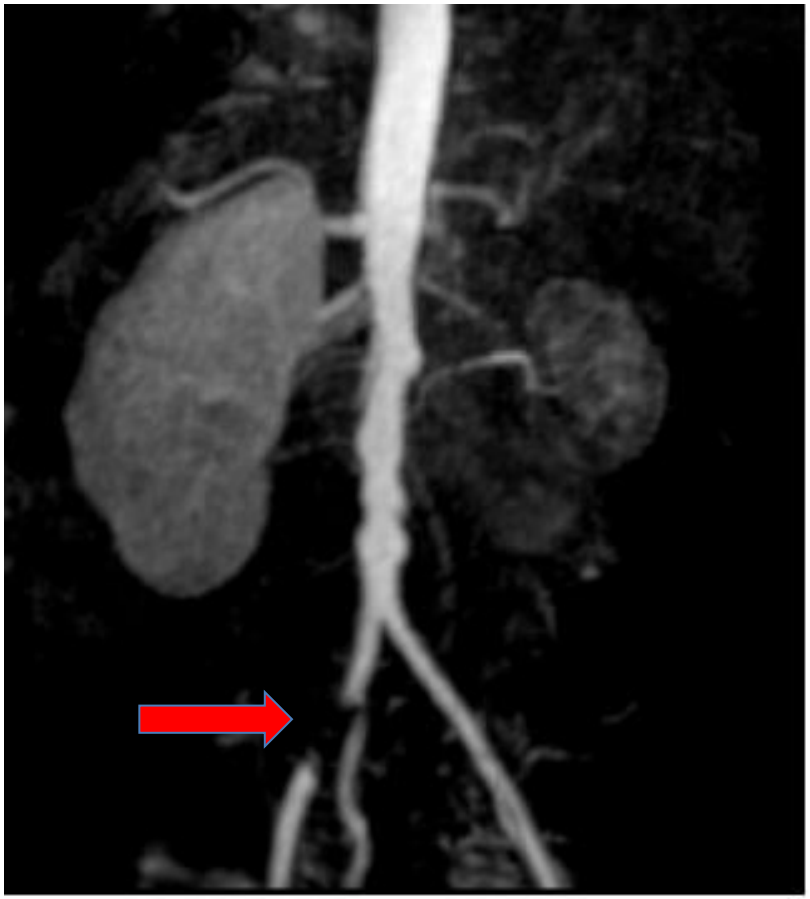
Lumen within a steel stent may be completely obscured



MRA for PAD: Limitations

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- Lower spatial resolution (1-1.5mm)
  - Overestimation of stenoses in small vessels
- Poor Ca^{+2} visualization / No bony landmarks
- Length of study (~30 min)
  - Uncooperative patient
  - Claustrophobia

MRA for PAD: Limitations

Risks / Contraindications

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- Implanted Metal Devices
  - Pacemaker/ICDs (relative)
  - Electronic devices
  - Infusion pumps
  - Implants & surgical clips

MRISAFETY.COM

- Gadolinium Contrast
  - Allergic reaction
  - Pregnancy
  - **Use Group II GBCA in GFR<30 ml/min/m2*

Nephrogenic Systemic Fibrosis

Imaging Advanced Renal Failure Pts (GFR<30 & not already on HD)

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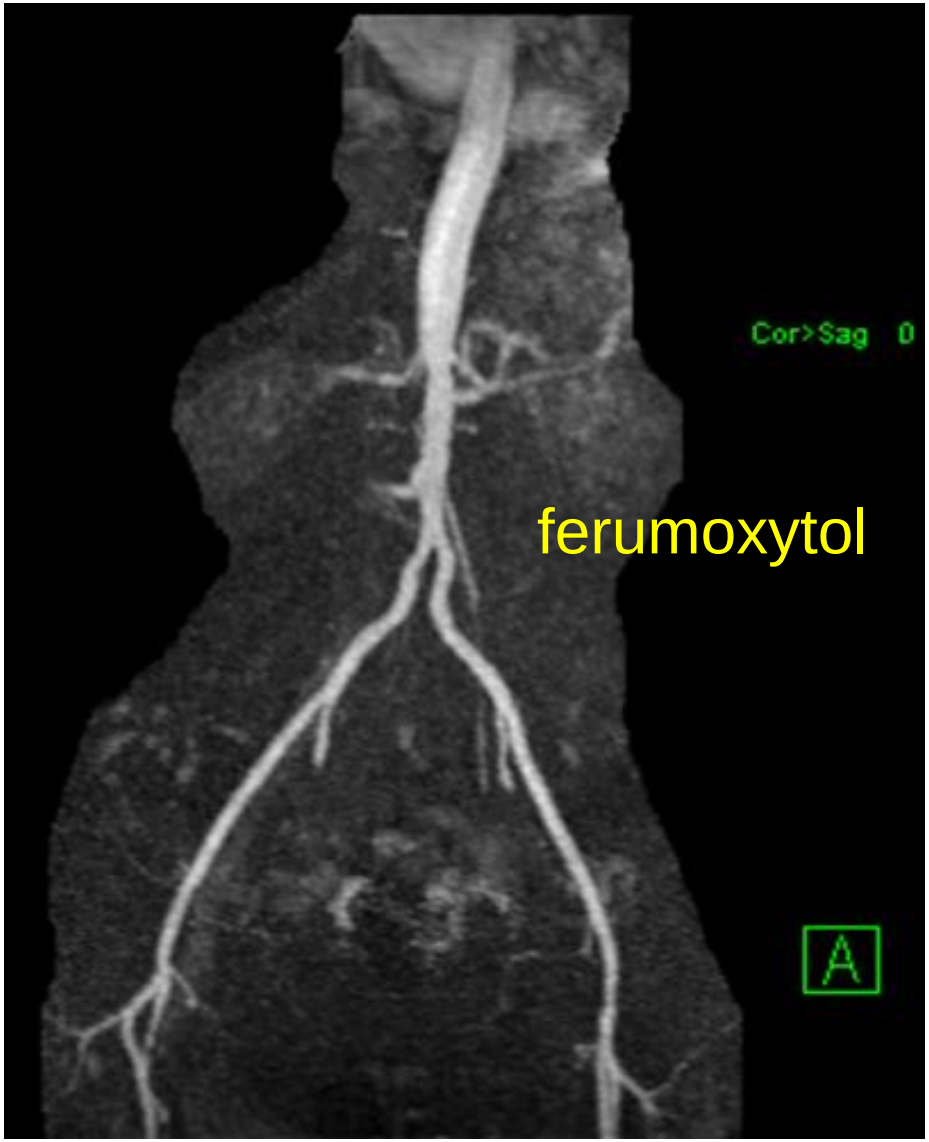
- Imaging options for?
  - Ultrasound
  - Non-contrast MRA (TOF)
  - Group II GBCA
  - *Ferumoxytol*
    - Ultra-small Iron oxide agent
    - Demonstrates super-paramagnetic properties during MR imaging
    - Indicated for treatment of Fe deficiency anemia in CKD



2016 AHA/ACC Guideline on the Management of Patients With Lower Extremity Peripheral Artery Disease: Executive Summary

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Recommendations for Imaging for Anatomic Assessment

COR	LOE	Recommendations
I	B-NR	Duplex ultrasound, CTA, or MRA of the lower extremities is useful to diagnose anatomic location and severity of stenosis for patients with symptomatic PAD in whom revascularization is considered.[100–103]
I	C-EO	Invasive angiography is useful for patients with CLI in whom revascularization is considered.
IIa	C-EO	Invasive angiography is reasonable for patients with lifestyle-limiting claudication with an inadequate response to GDMT for whom revascularization is considered.
III: Harm	B-R	Invasive and noninvasive angiography (ie, CTA, MRA) should not be performed for the anatomic assessment of patients with asymptomatic PAD.[104–106]

Herman. Circulation. 2017;135:e686–e725

Test Advantages in the Assessment of PAD

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CTA

- Better patient acceptance
- Rapid acquisition
- Higher spatial resolution
- Stent evaluation
- Soft tissues and bone also imaged
- Implanted metal devices

MRA

- Both contrast enhanced and non-contrast enhanced techniques available
- No interference from calcification
- Less nephrotoxic contrast
- Radiation free
- Repeat imaging

Both provide excellent anatomical assessment

Test Choice Based on Patient Specific Factors and Safety Profile

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Know local availability and expertise
First determine contraindications

CTA

- Critically ill/less cooperative/claustrophobic patients
- Stent analysis
- For patients on dialysis
- Small vessels
- Implanted metal devices

MRA

- Function and flow studies
- Repeated exams or younger patients
- Heavily calcified vessels
- Diabetics (Ca++, CRI)
- Iodine allergies
- Ferumoxytol for GFR<30 not on HD

An Algorithm for Choosing the Appropriate Imaging Modality for a Given Clinical Scenario

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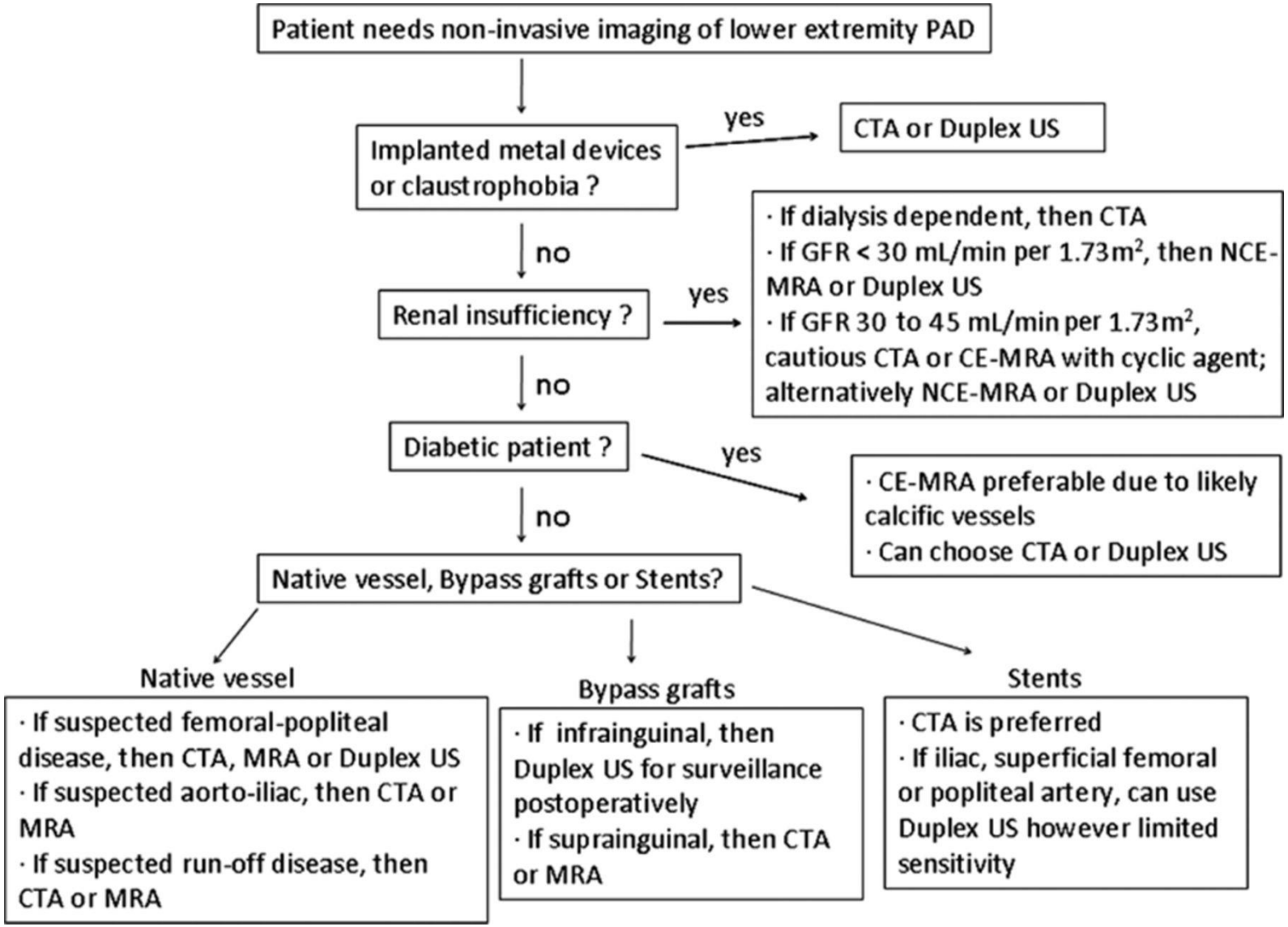

Pollak A W et al. Circ Cardiovasc Imaging. 2012;5:797-807

Take Home Points

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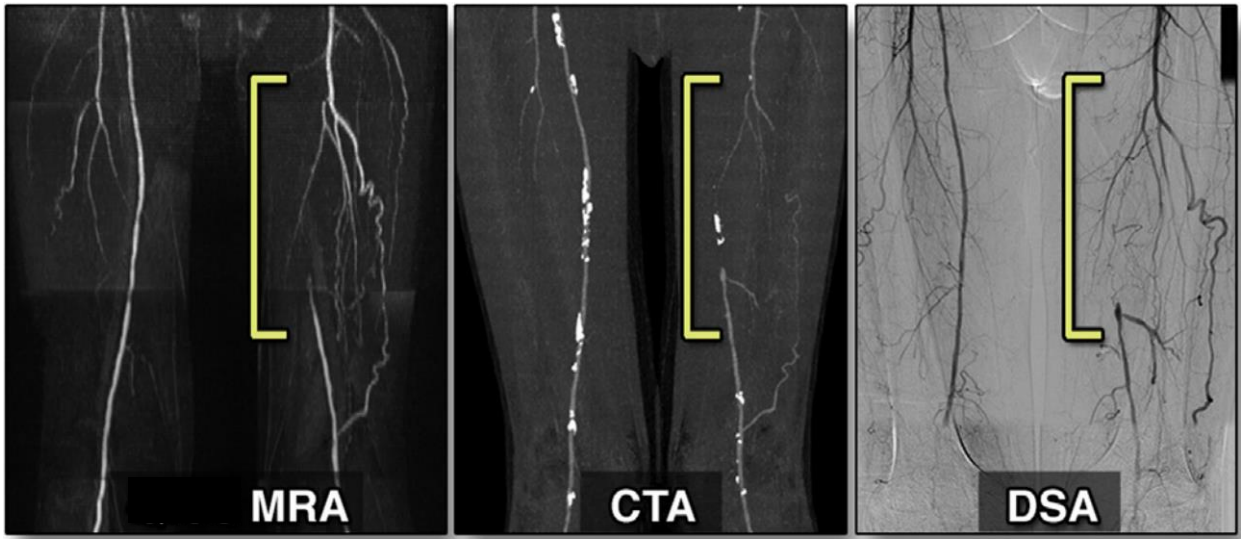
- Consider advanced imaging in patients with PAD who are candidates for revascularization
- Both CT and CMR have excellent diagnostic accuracy (as compared to DSA)
- Choice of test is based on local expertise and individual patient characteristics



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