BEYOND IMAGING

RC 312B *29 November 2016* *0830 – 1000*

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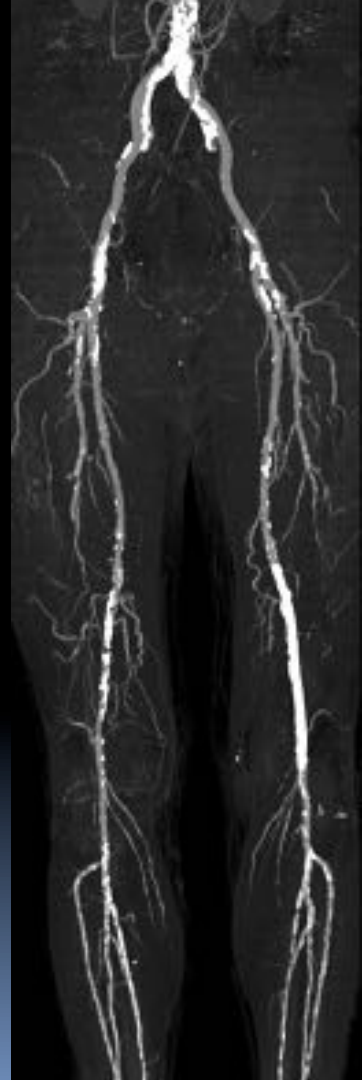
PERIPHERAL CTA



Outline

- Goals of LE CTA
- CTA Acquisition Techniques
  - Scan Acquisition
  - Contrast Medium injection
  - Reconstruction
- Clinical Efficacy in PAD

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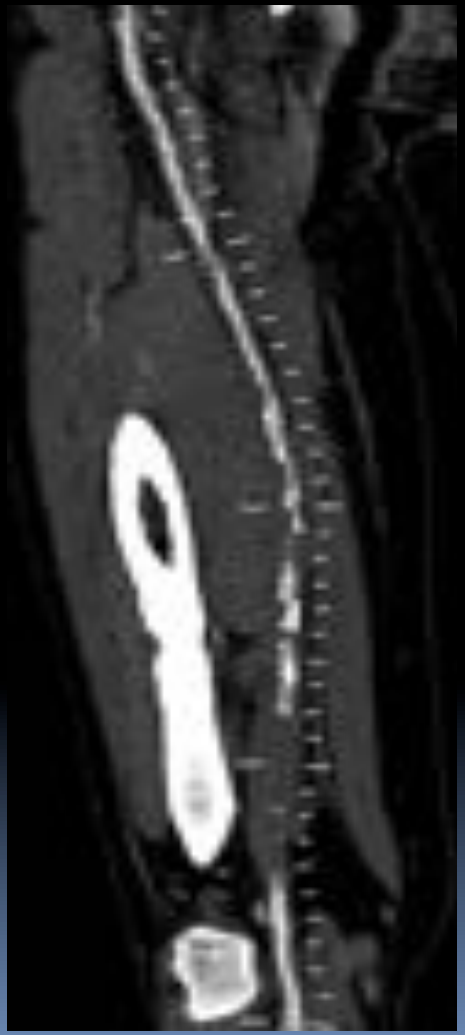
Goals of CTA imaging in PAD

Diagnosis and Staging of PAD

= symptoms + ABI

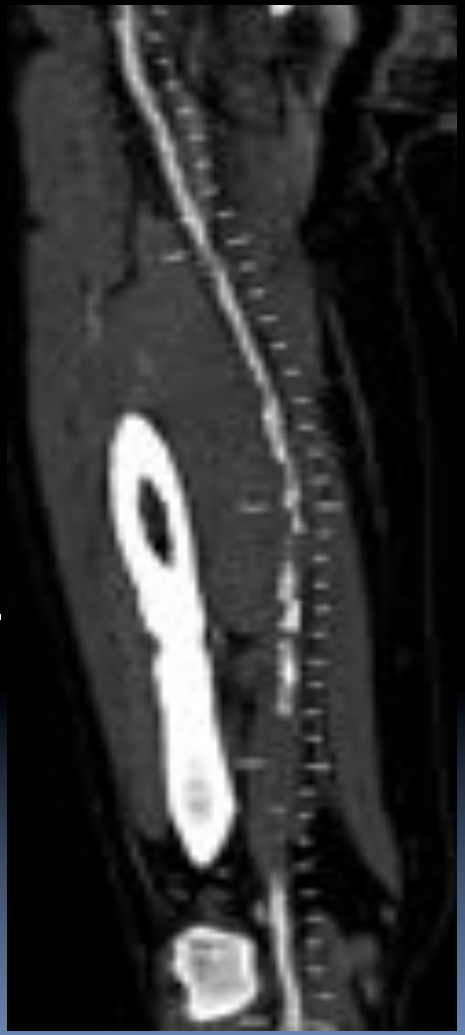
poor correlation of symptoms and ABI with number, location and severity of lesions

Example: calf claudication can be caused by isolated disease or combination of iliac and/or femoropopliteal lesions



Role of CTA Imaging is **NOT** diagnosis / staging

CTA role is to map lesions to the patient's symptoms for treatment planning



Goal of Reporting LE CTA

- Answer the clinical questions
  - NEED to get history
  - Intermittent Claudication vs Critical Limb Ischemia?
- Organize by leg:
  - Aorto-iliac (inflow)
  - Femoropopliteal
  - Below Knee runoff
  - Pedal vessels (2 cross ankle)

Indications for CTA in PAD

- Intermittent Claudication
- Critical Limb Ischemia
- Acute Ischemia (urgent)
- Monitoring of Therapy (complications)

Which lesions matter?

Treatment Segment	Aka, utility
Aorto-iliac	"Inflow", "Supra-inguinal"
Common Femoral a.	Bypass target and source
Profunda Femoris a.	Important collaterals w/ SFA occlusion Important s/p amputation
Femoro-popliteal (SFA-Pop)	"Infra-inguinal runoff" Note level of reconstitution above (P1) or below (P3) knee
Trifurcation vessels	"Infra-popliteal runoff" **Only relevant in CLI pts (not IC)**
Pedal aa.	"2 vessels crossing ankle" (DP, PT) **Only in CLI / bypass targets**

CTA Scan Acquisition

- Scan Acquisition
- Contrast Medium Injection

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Peripheral CTA
Scan Acquisition / Recon

Scanning Range 1

celiac artery (~T12) → toes

(105 – 130 cm)

Optional Scanning Range 2

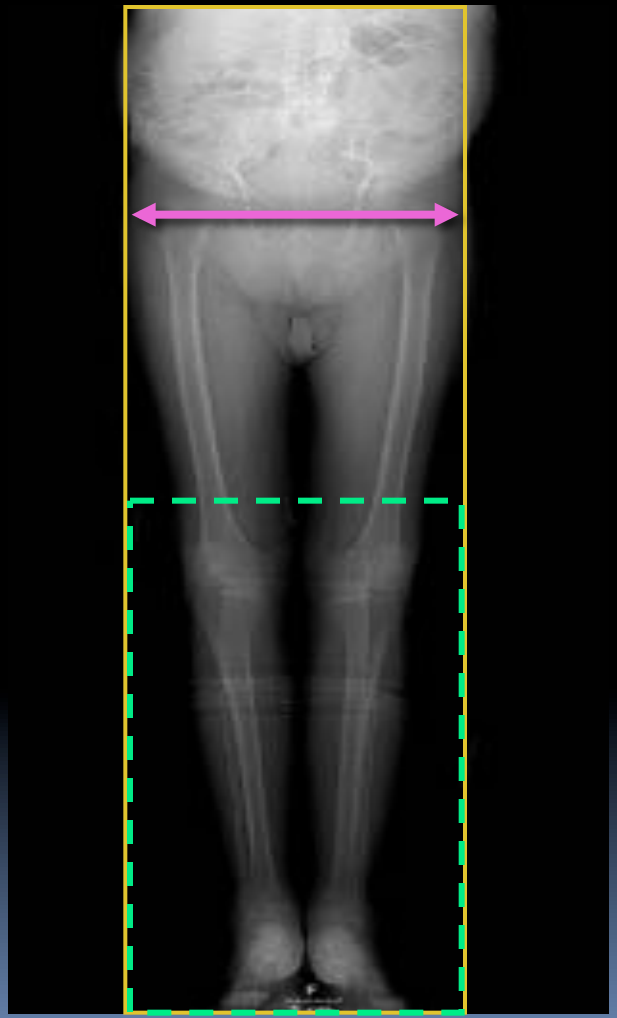
above the knees → toes

Always pre-programmed, but only initiated by RT if no contrast in pedal vessels

Recons:

Thin, overlapped

FOV = greater trochanters



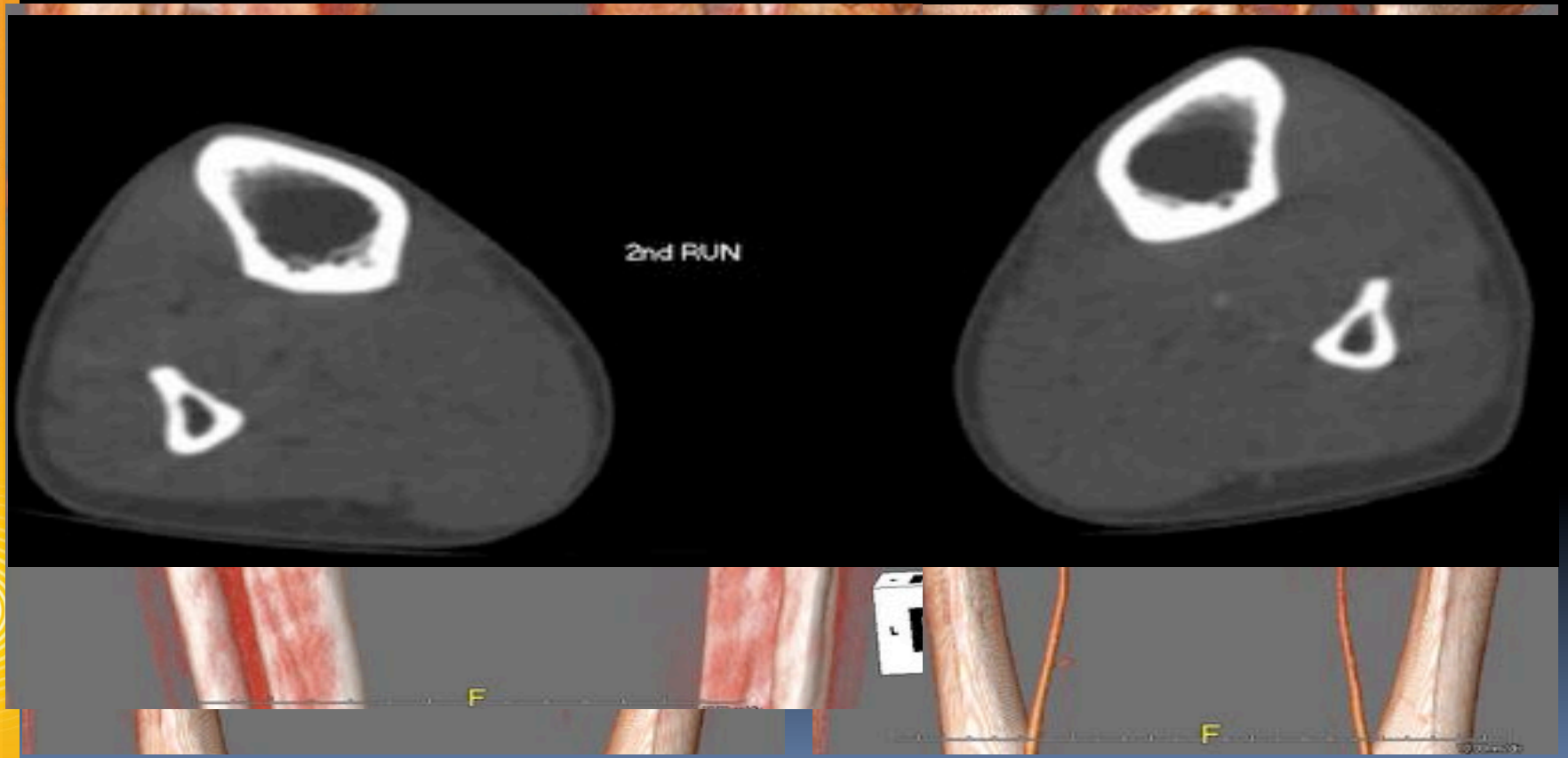
Anatomic coverage:
105 – 130cm

Detector Configuration (mm)	TI / 360° (mm)	Table Speed (mm/s)	Scan Time (s)		
16-Channel MDCT					
16×.75	18	36	30-40	slow	~35 mm/s
16×.63	18	35	30-40	slow	
16×1.5	33	66	15-20	fast	~65 mm/s
16×1.25	35	70	15-20	fast	
64-Channel MDCT					
64×.63	55	92	11-14	very fast	~85 mm/s
64×.60	29	78	13-17		
FLASH Modes					
128 x 2 x 0.60	128	458	< 3	BLAZING	
192 x 2 x 0.60	184	737	<2		

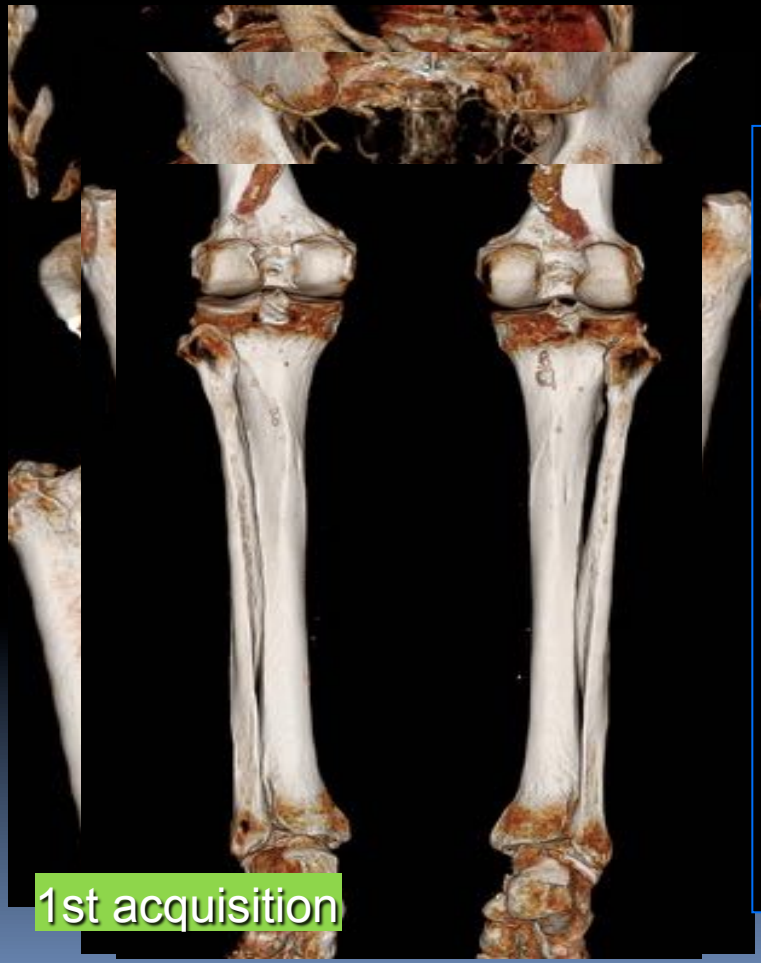
Speed considerations for ≥64 slice CTA

- Outrunning Bolus
- Delayed filling of distal arteries

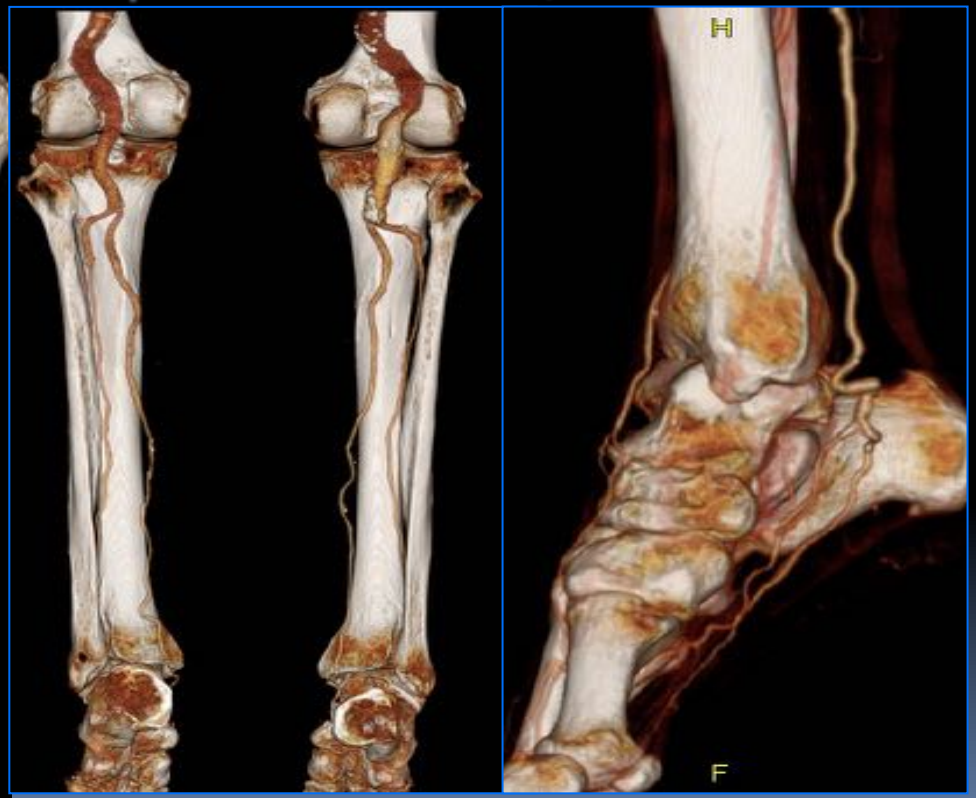
Free-Flap Planning CTA



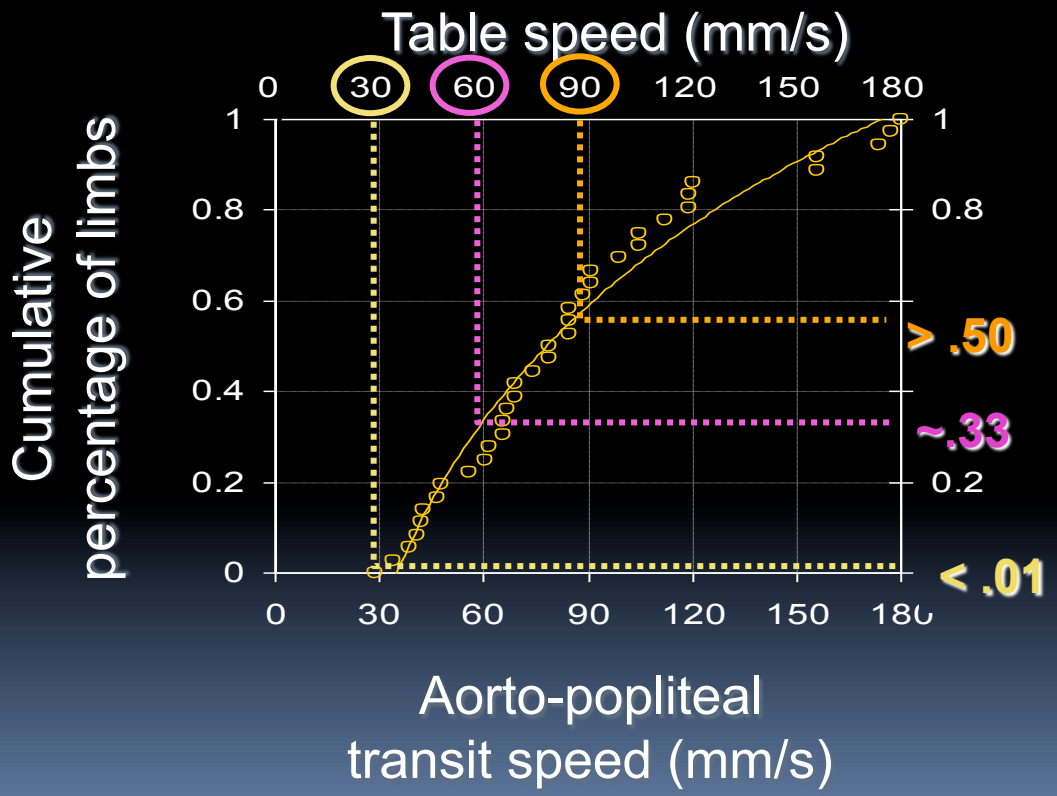
Arteriomegaly



preprogrammed,
optional 2nd acquisition

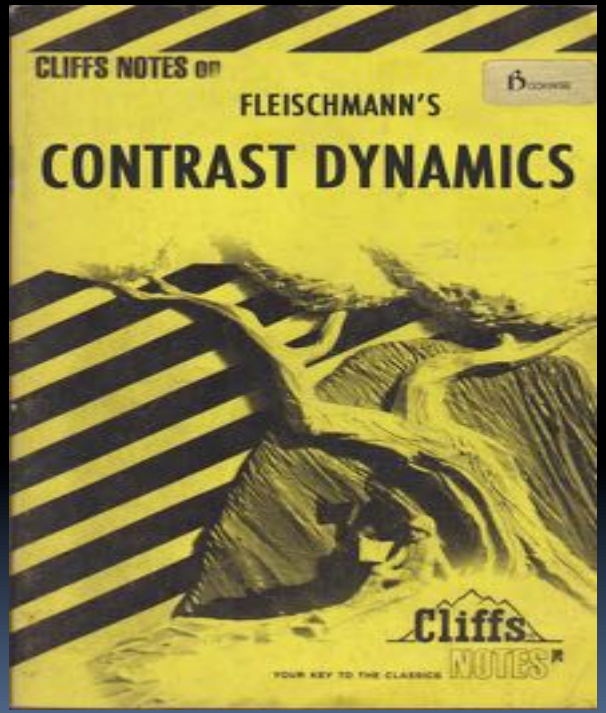


Peripheral arterial bolus propagation



Fleischmann D and Rubin GD. Radiology 2005, 1076-1082

Contrast Administration for peripheral CTA



Fleischmann D. How to design injection protocols for multiple detector-row CT angiography (MDCTA). Eur Radiol. 2005 Dec 1;15 Suppl 5:E60–5.

Contrast considerations for peripheral CTA

- Aorto-popliteal transit time: 4-24 sec (10 sec)
  - Contrast speed: 29-177 mm/s
- Biphasic injections yield more consistent enhancement profile

Fleischmann et al. JVIR 2006, 17(1) 3-26.

Biphasic Injection for Peripheral CTA

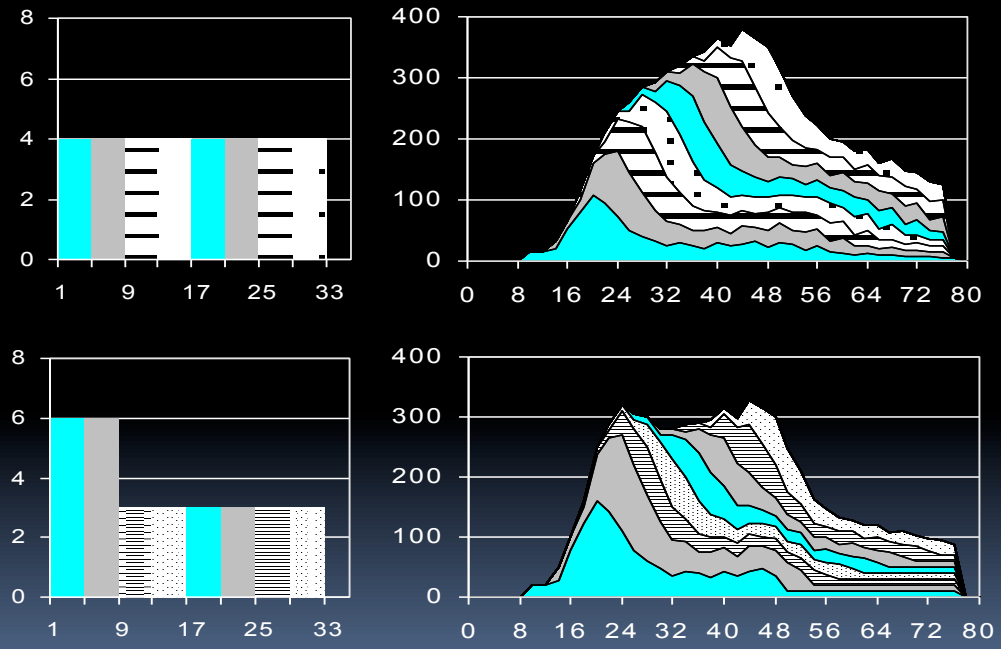
Fleischmann D. Eur. J. Radiol. 2003 Mar 1;45 Suppl 1:S88–93.

INPUT
intravenous injection rate (mL/s)

OUTPUT
arterial enhancement (ΔHU)

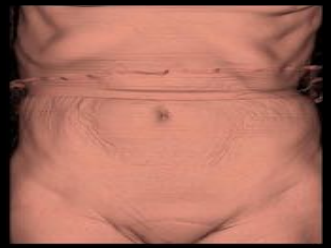
Biphasic Injection

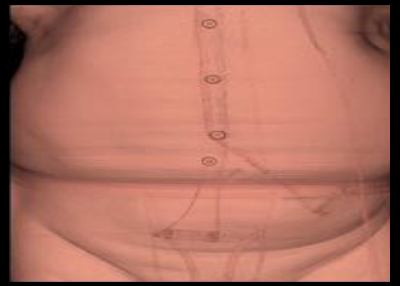
Phase I
(surge phase)



Phase II
(continuing phase)

Patient Factors





- Arterial enhancement is **inversely** related to:
  - Cardiac output (CO)
  - Central blood volume (CBV)

} usually unknown

  - CO (and CBV) correlate with body weight
    - at least in pts. with ~ normal cardiac function
  - Weight-based dosing helps consistency

[1] Hittmair & Fleischmann, JCAT 2001

Integrated Contrast/Scan Protocol

- Simple, weight based injection volumes and flow rates, combined with a fixed scan time or scan time/diagnostic delay sum.
- automated bolus triggering
- Use physiology (not scanner speed)
- BENEFITS:
  - Decrease patient to patient variability in scan quality
    - Optimize imaging timing
    - Image all of the contrast given!
  - (Potentially) save contrast

STANFORD Integrated Scanning-Injection Protocol: (Siemens)

- Scan time: 40s for ALL patients (pitch variable)
- Inj.duration: 35s for ALL patients
- Delay: bolus triggering

weight	Biphasic Injection
<55kg	20 mL (4.0mL/s) + 96 mL (3.2mL/s)
<65kg	23 mL (4.5mL/s) + 108 mL (3.6mL/s)
75kg	25 mL (5.0mL/s) + 120 mL (4.0mL/s)
>85kg	28 mL (5.5mL/s) + 132 mL (4.4mL/s)
>95kg	30 mL (6.0mL/s) + 144 mL (4.8mL/s)

ST. VINCENT Integrated Scanning-Injection Protocol: (GE HD-750, VCT)

- Scan time: Variable (can't specify time)
- Add "diagnostic delay" to make 40 sec
- Inj.duration: 35s for ALL patients
- Delay: bolus triggering

weight	Biphasic Injection
<55 kg	20 mL (4.0mL/s) + 96 mL (3.2mL/s)
55–95 kg	**25 mL (5.0mL/s) + 120 mL (4.0mL/s)**
>95 kg	30 mL (6.0mL/s) + 144 mL (4.8mL/s)

Special Scenarios

- Renal Dysfunction
- Contrast Medium Savings

Adaptations for Renal Dysfunction: LESS IS MORE

- Decrease CM dose
- Decrease kV imaging
- Decrease scan range

Background:

- There is clinical evidence that ratio of CM to eGFR can predict CIN occurrence
- Best discriminator: CM dose (mL) ≥ 3.7 x eGFR
  - Corresponds to 1 x eGFR in grams of iodine (assuming 370 mg I / mL contrast)
- There is also evidence that CIN risk is not increased for volumes less than 2.0 mL x eGFR (PCI data)

Gurm HS, et al. J Am Coll Cardiol 2011; 58:907-14

eGFR-based CM calculation

- Determine eGFR : http://touchcalc.com/e_gfr
- If eGFR < 60 ml/min/m² (e.g.CKD):

MAX volume (mL) = eGFR x 2

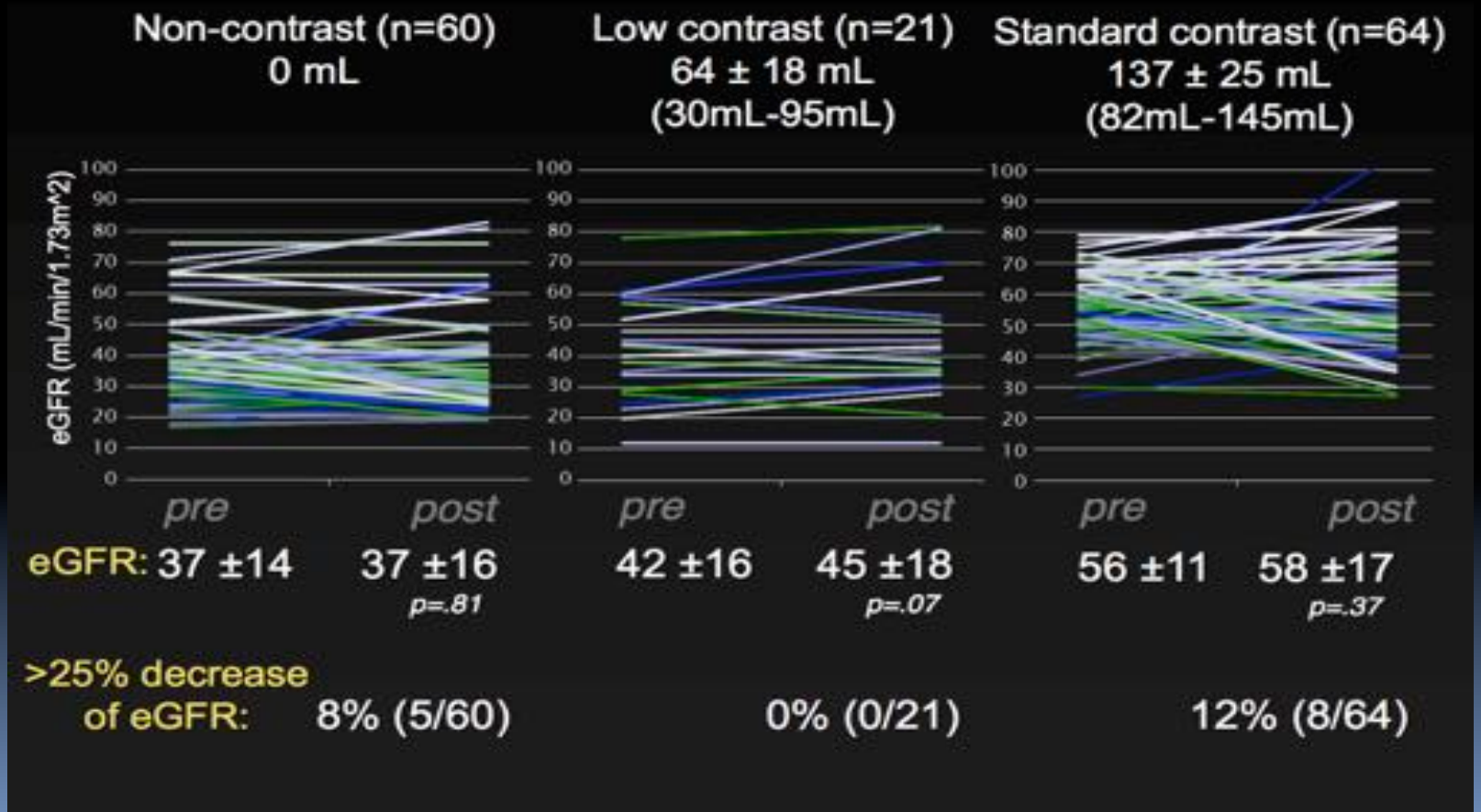
(this is for 75 kg body weight)

Then, adjust for BW:

MAX volume = eGFR x 2 x (BW/75)

** Low concentration CM (300 mgI-/mL)

eGFR before and 3-14d after CTA in 185 pts undergoing TAVR



Courtesy: D. Fleischmann, MD

Low kVp Imaging

	140 kVp	120 kVp	100 kVp	80 kVp	70 kVp
Iodine Attenuation (compared to 120 kVp)	- 25%	-	+25%	+50%	+70%

- K-edge of iodine: 33.2 KeV
- Attenuation of iodine increases by 25% from 120 to 100 kVp, and again from 100 to 80 kVp
- Each "step" down in kVp corresponds to ~ 25% less CM needed

Chapter 3: Contrast Medium Injection Technique. In: Schoepf and Meinel, eds. Multidetector-Row CT of the Thorax (2016)

Low kVp imaging - modifications

- Keep injection duration, scan-time, and scan delays constant
- For each "step" down in kVp, increase mAs 30-50%
- Noise Control options:
  - Slow pitch down
  - Slow gantry rotation time
  - Keep noise index the same
  - Match $CTDI_{vol}$ between protocols

Other issues in low kVp imaging

- Ca++ blooming / metal beam hardening worsens
- Larger focal spot requirement decreases spatial resolution (focal spot bloom)
  - Improved w newer scanner technology

CTA Reconstruction

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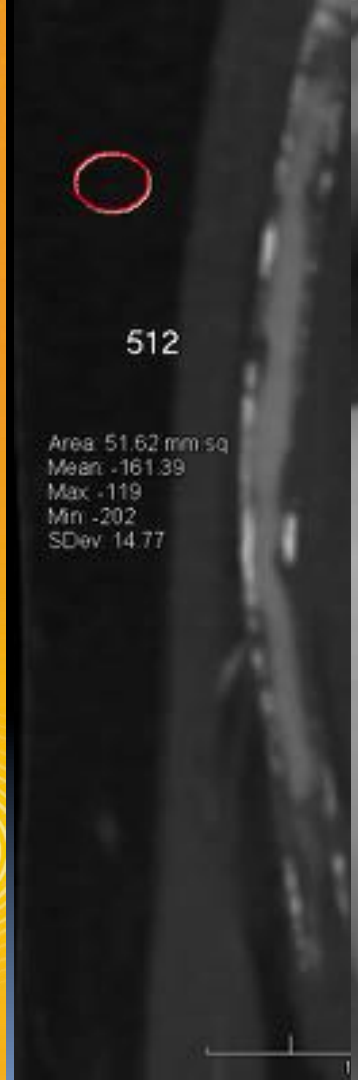
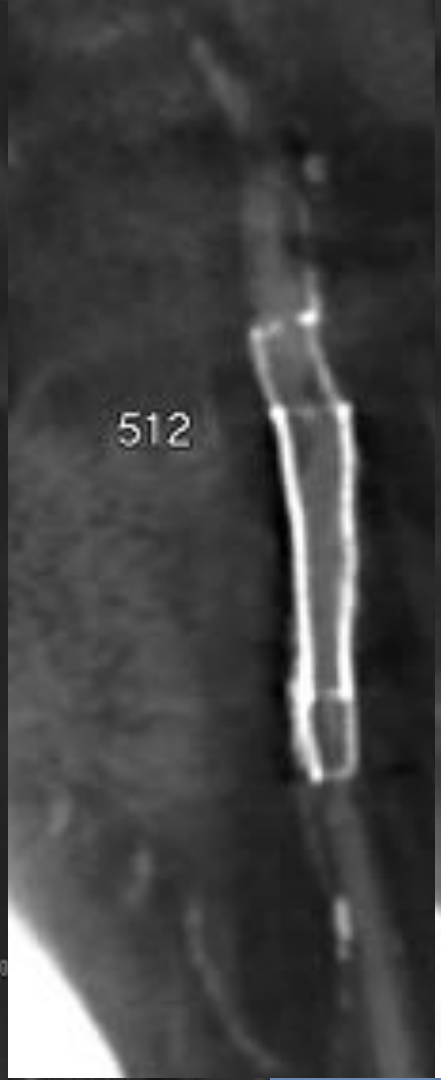
Tips: CTA Reconstruction and Interpretation

- Use smaller FOV (trochanter to trochanter)
- Use Iterative Reconstruction
- Recon thin, overlapping images and review in 3D
  - VR / MIP overview then MPR, CPR
  - 3 -5 mm Axials in A/P
- Recon larger matrix – 1024x1024

** *Fleischmann D, Hallett RL, Rubin GR.* **JVIR 2006, 17: 3-26**.


512
Area: 51.62 mm sq
Mean: -161.39
Max: -119
Min: -202
SDev: 14.77


1024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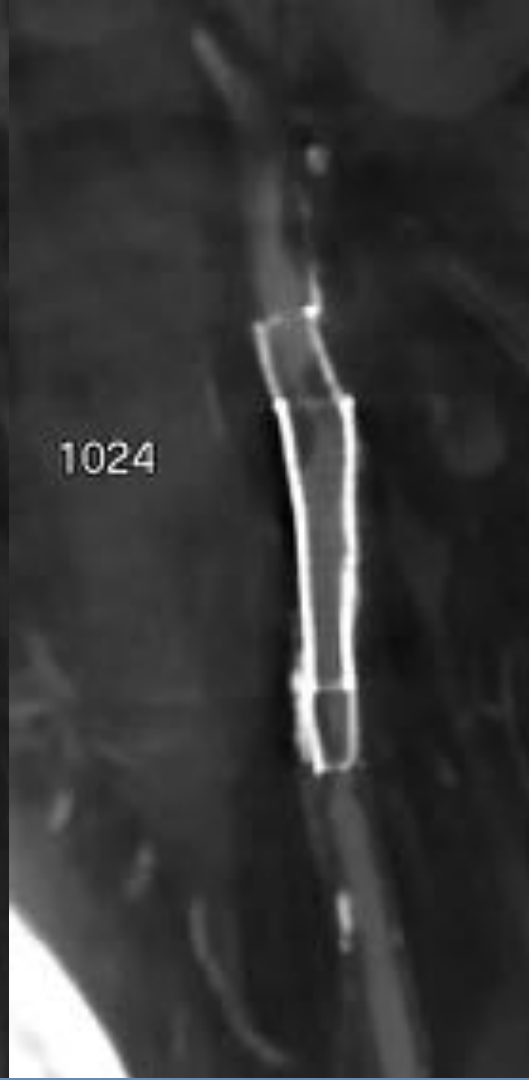

1024

CTA Post-processing Tips

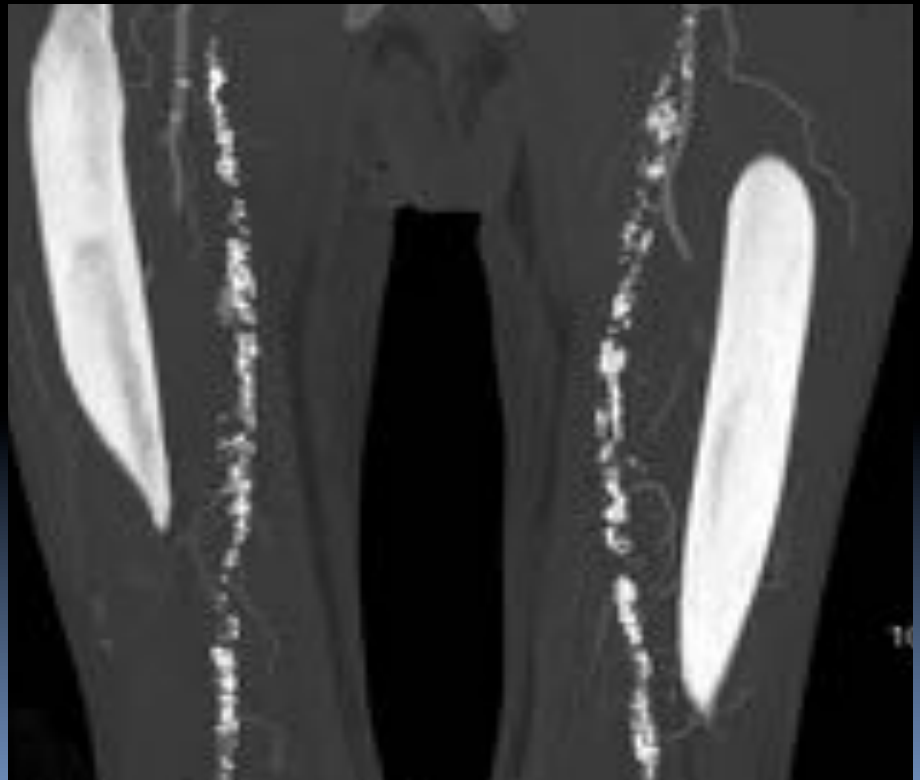
- Big challenge in lower extremity CTA:

  difference between quick read vs. painful (literally) scrolling through images
- axial (transverse) images inadequate, except in acute ischemia (i.e. thromboembolic)
- Volumetric review of volumetric datasets!

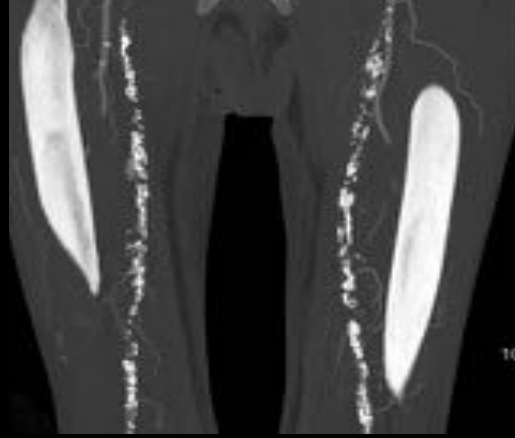
CTA Post-processing Tips

- need longitudinal cross sections (MPR/CPR)
- Map lesions with a 'map':
  - multipath curved planar reformations (MPCPR)
  - CPRs made on 3D Solution
- try to delegate (3D-Lab, trained technologist) if routinely performing runoff CTAs

The Achilles' Heel of Extremity CTA.....



Predictors of Vascular Calcification

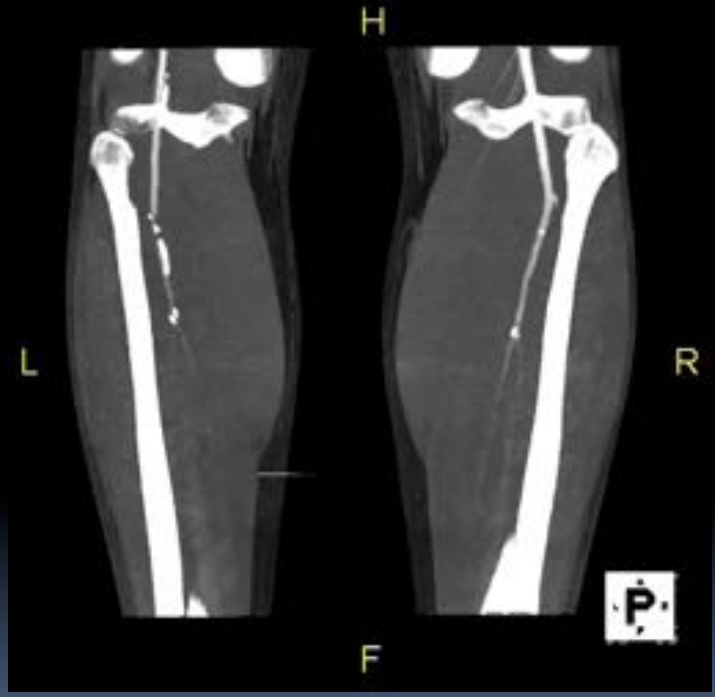


- Above knee:[1] Severe PAD (Fontaine III-IV), Diabetes
- Below Knee:[1] Renal Failure (esp. dialysis), Diabetes
- Also:[2] Age, cardiac disease
- If heavy, significant decrease in SENS/SPEC in calf [1]

[1] Meyer BC Eur Radiol (2010) 20:497-505
[2] Ouwendijk R. Radiology (2006) 241, 603-608

Time-Resolved CTA - Runoff

- Technique
  - timing bolus at popliteal artery
  - 50 mL at 5 mL/ sec + 50 mL saline chaser
  - 12 low-dose CTA acquisitions over 30 sec
    - Rapid "shuttle" of detector array
- Then: standard CTA runoff protocol



- Significantly greater enhancement, less venous overlap
- Significantly higher diagnostic confidence
- Directly visualize asymmetric / delayed / diminished flow

Sommer Eur. Radiol (2010) 20: 2876-2881

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Efficacy of LE CTA in PAD

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CTA: Diagnostic Performance vs. DSA

Performance

CT Channels	Sens (95% CI)	Spec (95% CI)
2-4	92 (88-96)	98 (95-99
16-64	97 (95-98)	98 (96-99)

Detection of ≥50% Stenosis or Occlusion By Anatomical Region

Vessels	Sens (95% CI)	Spec (95% CI)
Aortoiliac	96 (91-99)	98 (95-99
Femoropopliteal	97 (95-99)	94 (85-99)
Trifurcation	95 (85-99)	91 (79-97)

Met R et al. JAMA 2009;301:415-424

Diagnostic Performance: 64-slice CTA

- Symptomatic PAD: 242 pts, 7420 segments
- CTA and DSA performed
- For >70% stenosis:
  - SENS/SPEC 96% PPV 98% NPV 99%
  - No sig difference vs DSA findings
  - Results similar in Ca++ vs. Non-Ca++ lesions

Napoli A. Radiology. 2011 Dec 1;261(3):976–86.

Clinical Utility of LE CTA in PAD

- Intermittent Claudication (IC)
- Critical Limb Ischemia (CLI)

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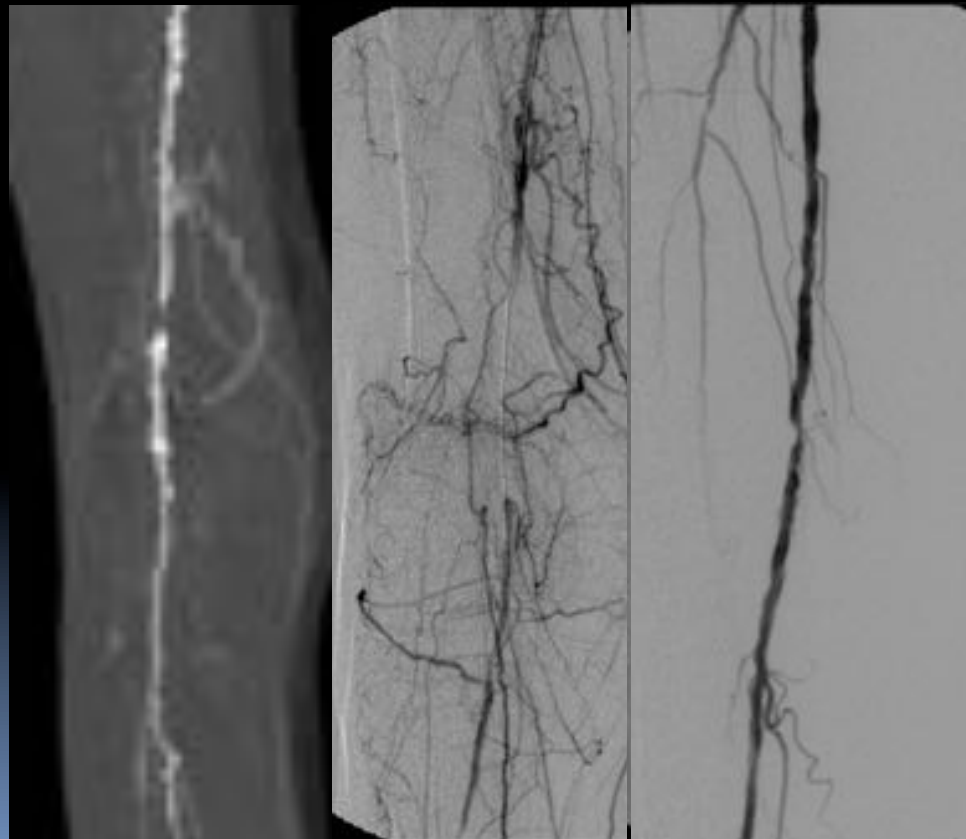
CTA Directed Management of Intermittent Claudication

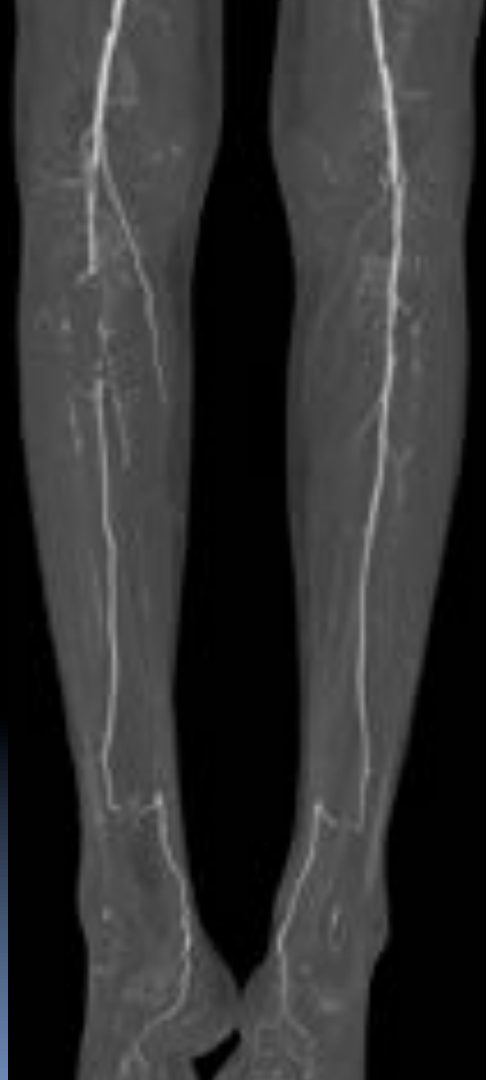


CTA Directed Management of Intermittent Claudication

- Fontaine IIb patients, Tx decisions by TASC II criteria
- 57/58 correct Tx decision-making by CTA
  - One CFA stenosis missed
  - 29 endovasc/surg Tx
  - 29 conservative mgmt

Schernthaner R, et al. AJR 2007; 189:1215-1222

CTA Directed Management of CLI



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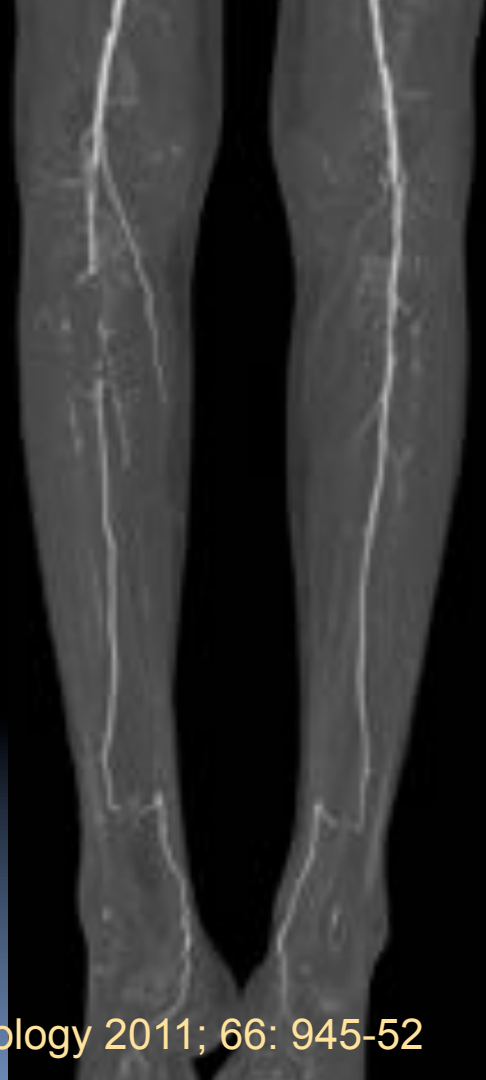
CTA Directed Management of CLI

- 41 pts, 1435 segments
- 64-CTA
- Fontaine IIb, III, IV
- 2.2% segments non-diagnostic
  - not included in calculation
  - 91% infrapop segments evaluable
- **For ≥ 50% stenosis:**
  - **Sens 99% Spec 98% Acc: 98%**



Fotiadis N, et al. Clinical Radiology 2011; 66: 945-52

CTA Directed Management of CLI

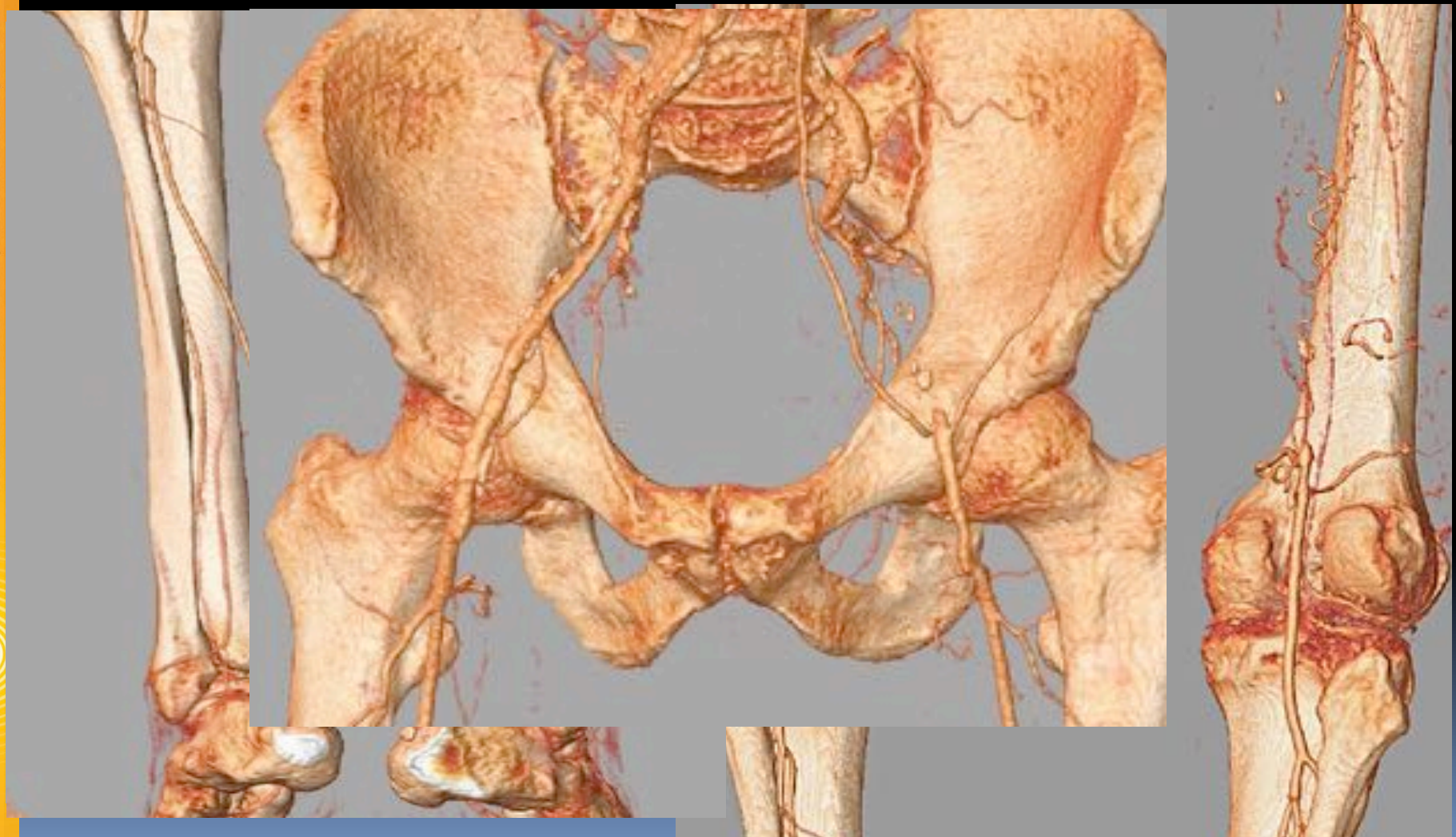
- 28 pts, Fontaine IV
- 64-detector CTA
- 14/28 → endovascular and/or surg. Tx
- correct decision-making for interventions, amputation, and medical Tx based on DSA and Tx response

Schernthaner R, et al. AJR 2009; 192: 1416-1424

Management of both IC and CLI by CTA

- Treated using TASC II guidelines
  - 49 conservative TX
  - 87 Endovascular
  - 38 surgery
  - 17 hybrid
- Tx recommendations from CTA same as DSA in all but ONE

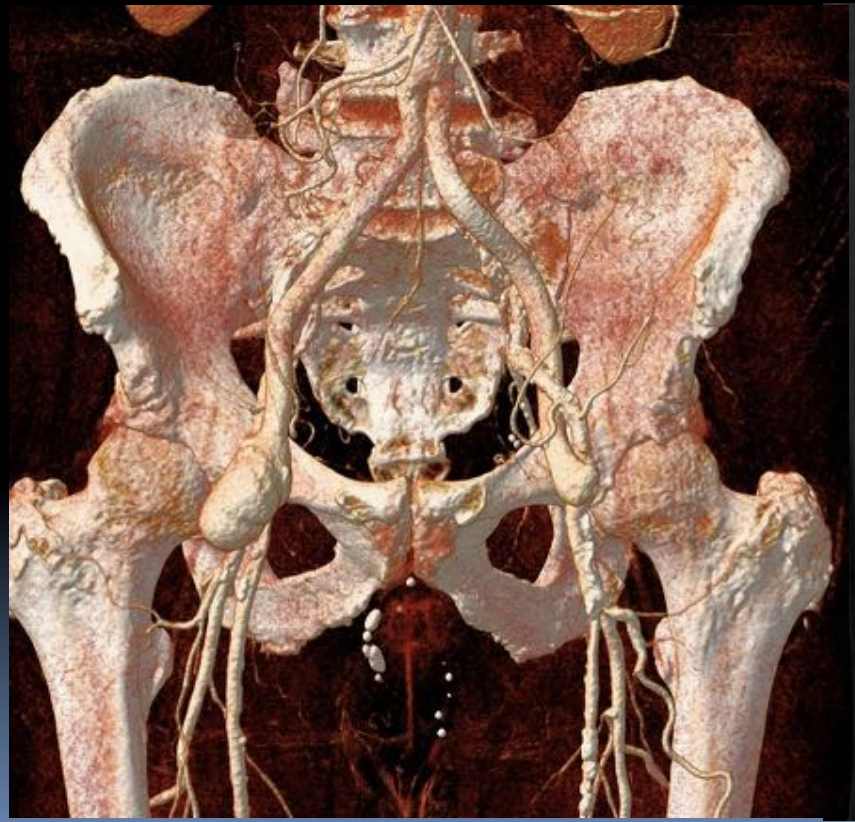
Napoli A. Radiology. 2011 Dec 1;261(3):976–86.

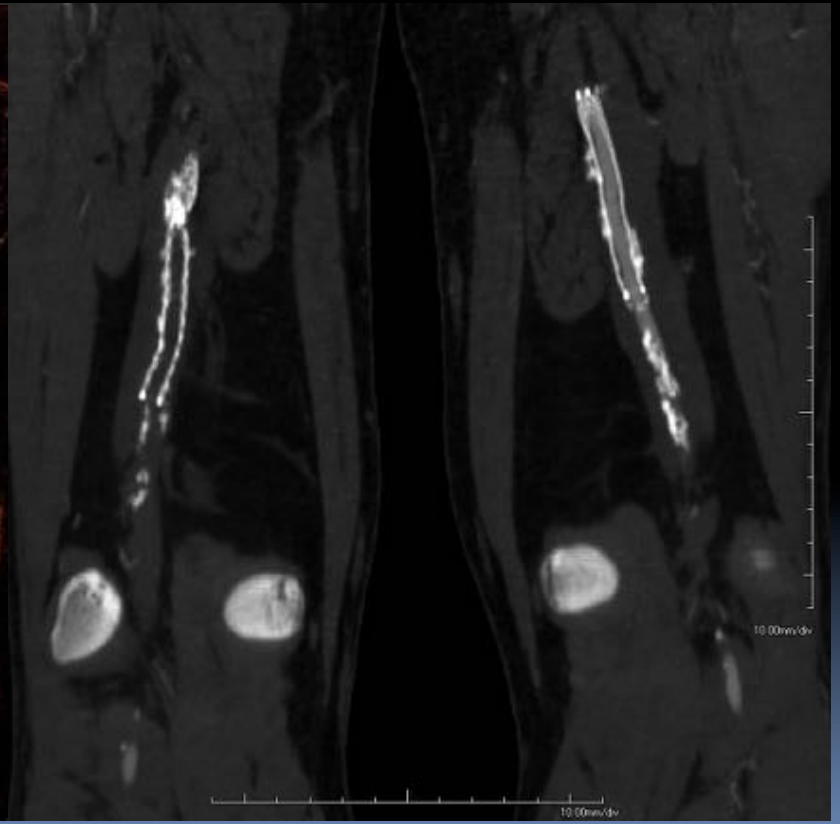


CTA for post-treatment followup

Willmann JK, et al. Radiology 2003; 229: 465-474.

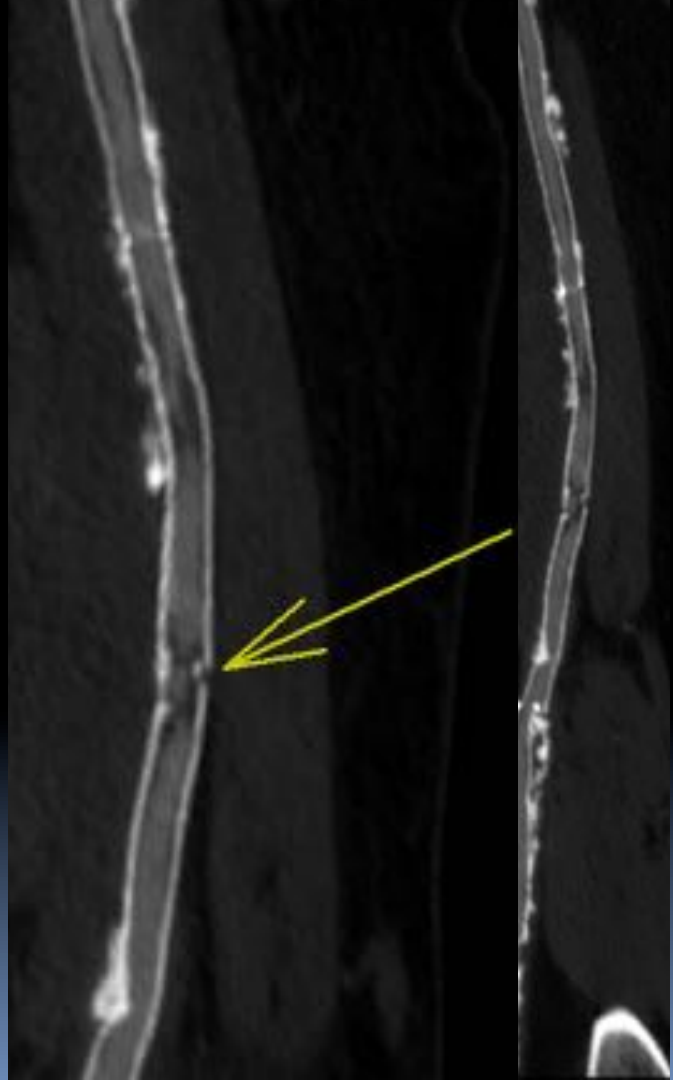
Post-TX Assessment by CTA





CTA for stent assessment

- Most stents assessable (76%) by CTA
  - Gold / platinum markers
  - Motion
  - Strecker stent (Tantalum): Increased luminal density [2]
- If evaluable, sens/spec ~ 95% for significant in-stent restenosis (vs. DSA)



[1] Li X, et al. Eur J Radiol 2010; 98-103
[2] Strotzer, Invest. Radiol. 2001:36(11)

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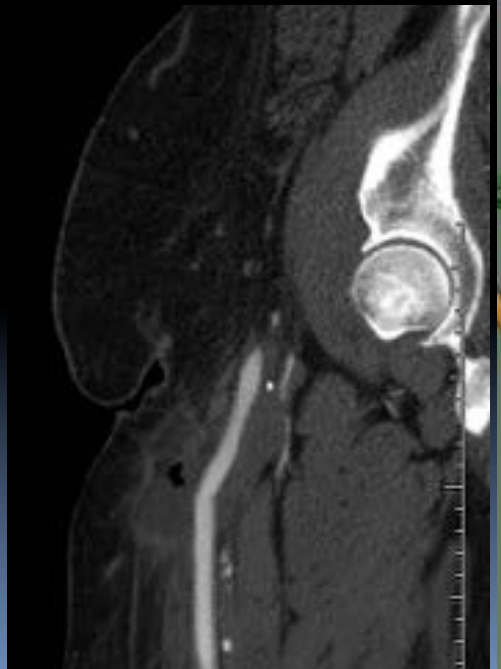
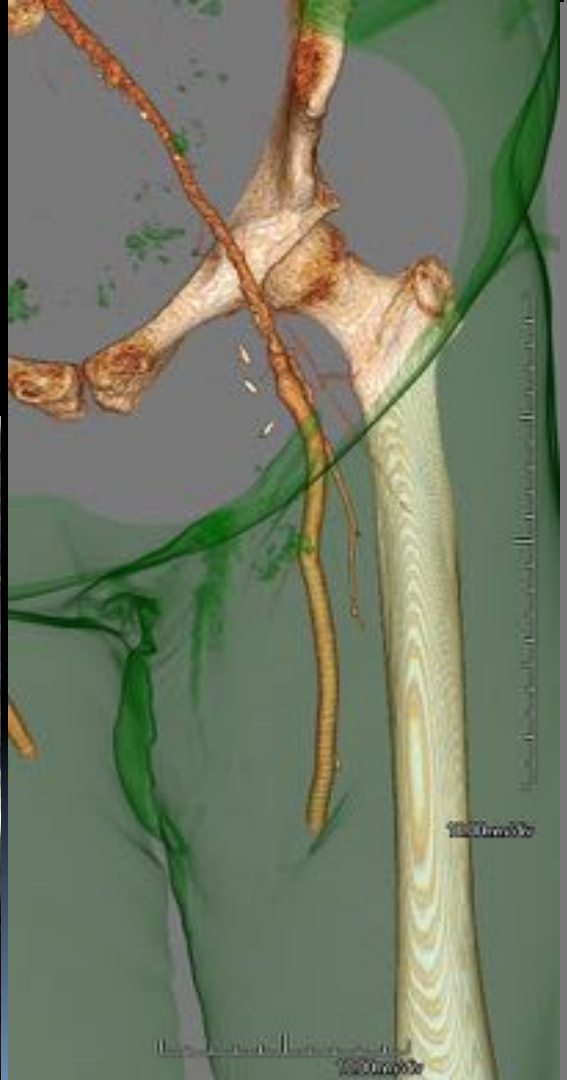
CTA for assessment of complications





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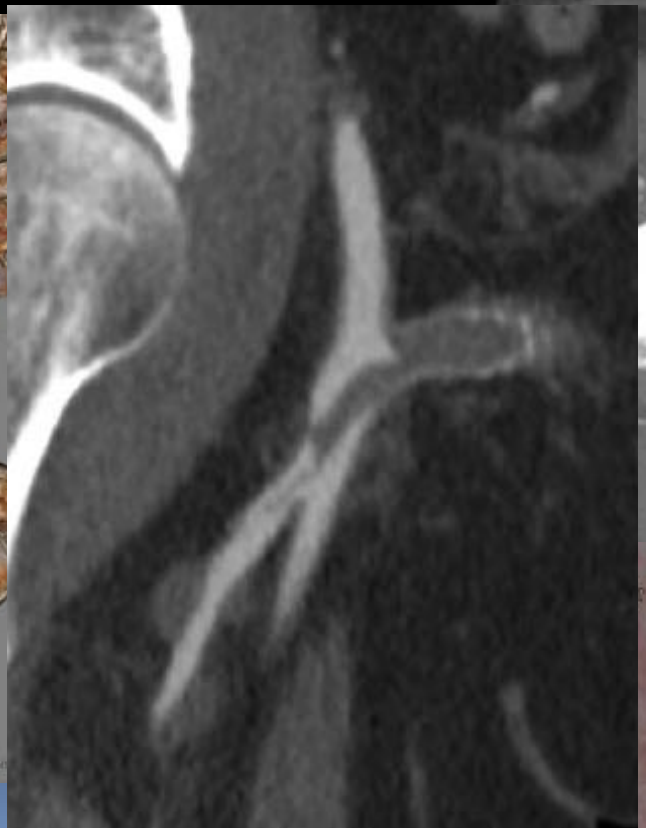
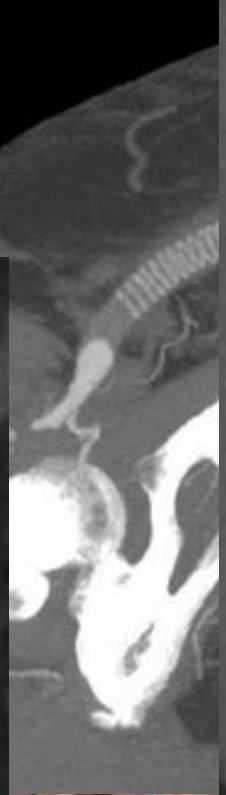
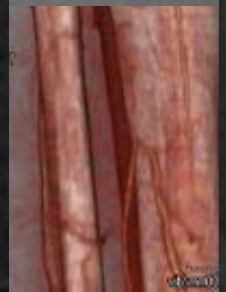
Acute R leg pain

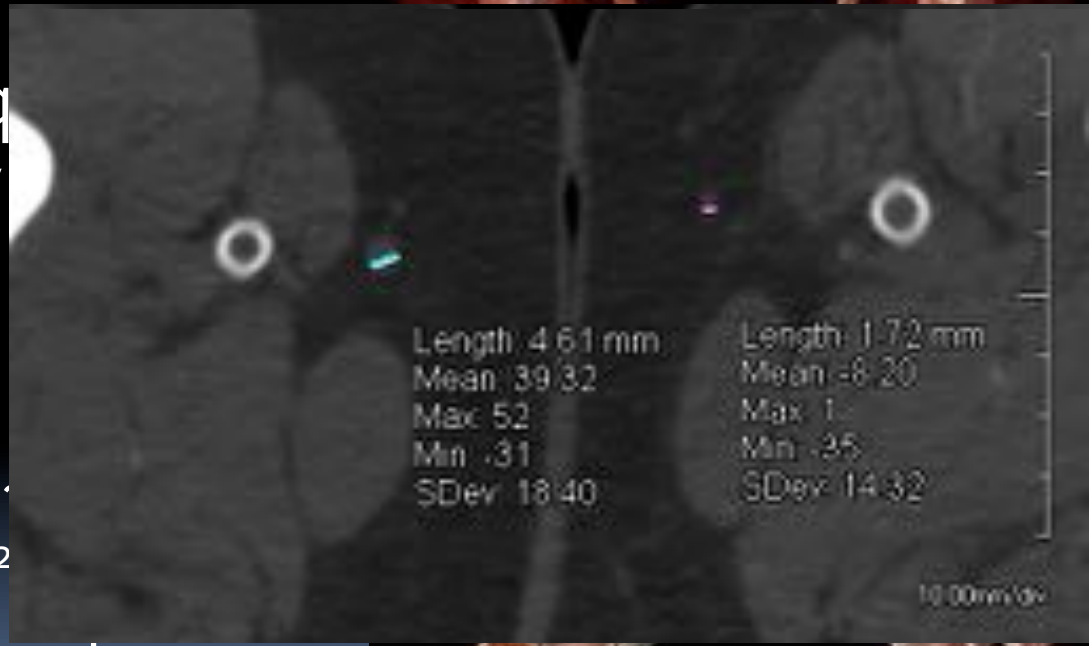






Value-Added Info from CTA: GSV mapping[1-2]

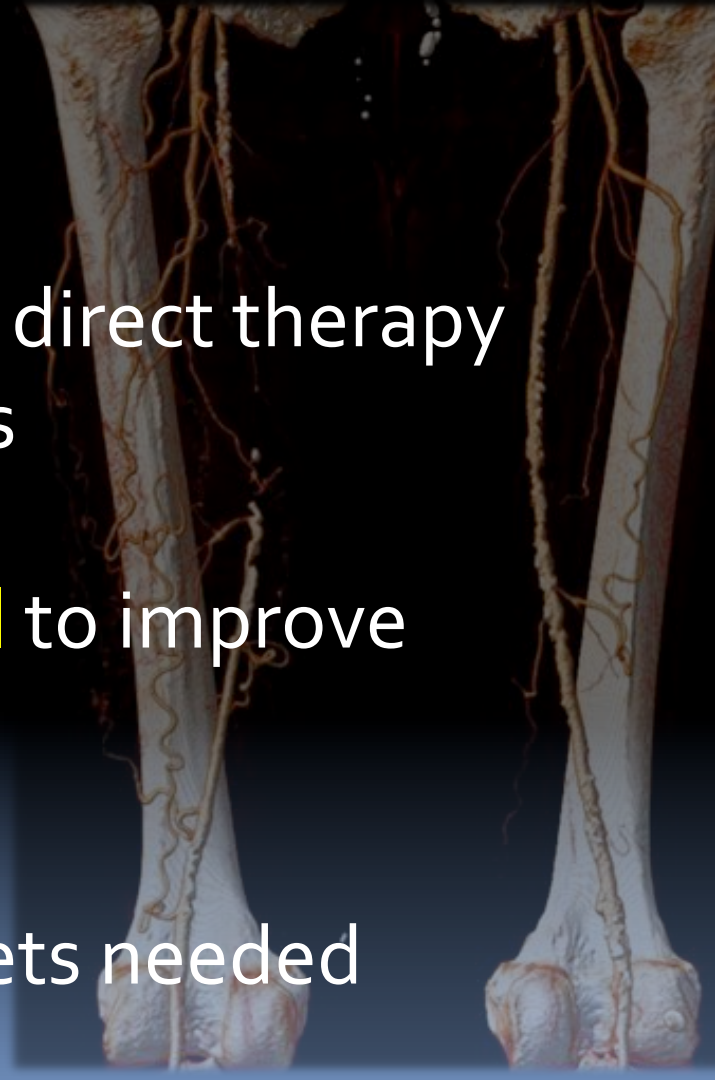
- Pre-Op CTA: Adeq
  evaluation of GSV
  - SENS/SPEC >90%
    thigh)
  - Charge savings of
    authors site alone[2]
  - If GSV ≤ 2 mm, then do
    Doppler US



[1]DeFreitas DJ, et al. J Vasc Surg 2013; 57(1): 5-55.
[2]Johnston WF, et al. J Vasc Surg 2012: 56(5) 1331-37.

Conclusions

- Goals:
  - Map lesions to symptoms to direct therapy
  - Answer the clinical questions
- Implement:
  - Integrated CM/scan protocol to improve consistency
    - Inject long, scan slow
    - Weight-based CM dosing
- 3D Volumetric Review of Datasets needed



Thanks for your Attention!

- Special thanks to…..

  Dominik Fleischmann, MD

@CTterrific

Handout: stanford.edu/~hallett choose folder "RSNA2016"