RC 612B *3 December 2015* *0830 – 1000*

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PERIPHERAL CTA

Outline

- CTA Acquisition Techniques
  - Scan Acquisition
  - Contrast Medium injection
  - Reconstruction
- Clinical Efficacy in PAD
- Cost Effectiveness

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CTA Indications in PAD

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

CTA Benefits / Limitations

- Non-invasive (DSA)
- Spatial Resolution (MRA)
- Quick Acquisition
- (mostly) Operator Independent

- Ionizing Radiation
- Nephrotoxic Contrast
- Spatial Resolution (DSA)
- No same session Tx
- No flow or pressure measurements

CTA Acquisition

- Scan Acquisition
- Contrast Medium Injection

CTA Scan Acquisition

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Peripheral CTA
Scan Acquisition / Recon

Scanning Range 1

celiac artery (~T12) → toes

(105 – 130 cm)

Optional Scanning Range 2

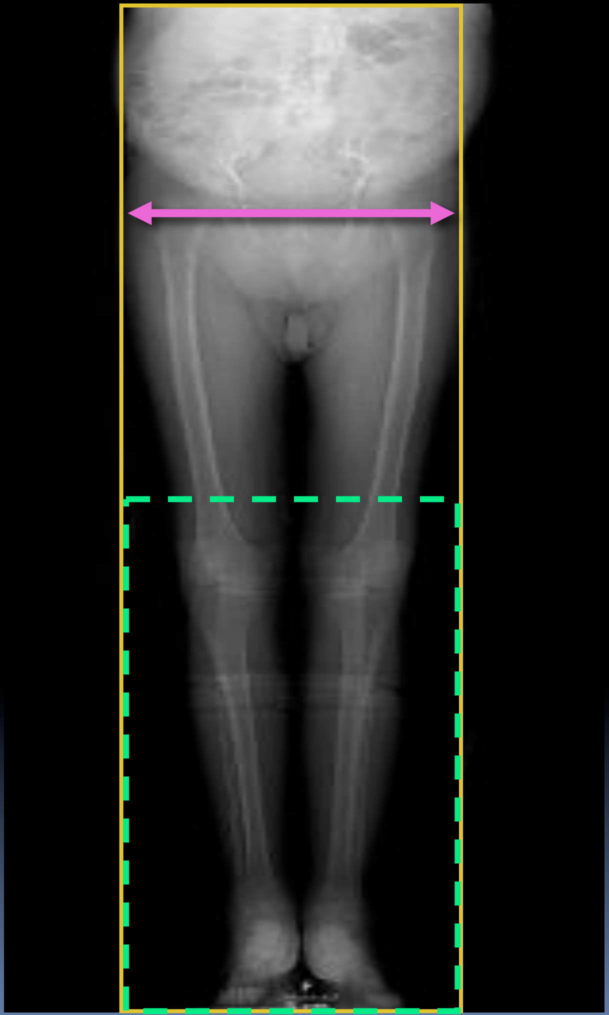
above the knees → toes

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

Recons:

Thin, overlapped

FOV = greater trochanters



Anatomic coverage: 105 – 130cm

16-Channel MDCT

Detector Configuration (mm)	TI / 360° (mm)	Table Speed (mm/s)	Scanning Time (s)
16×.75	18	36	30-40
16×.63	18	35	30-40
16×1.5	33	66	15-20
16×1.25	35	70	15-20

slow
slow
~35 mm/s

fast
fast
~65 mm/s

64-Channel MDCT

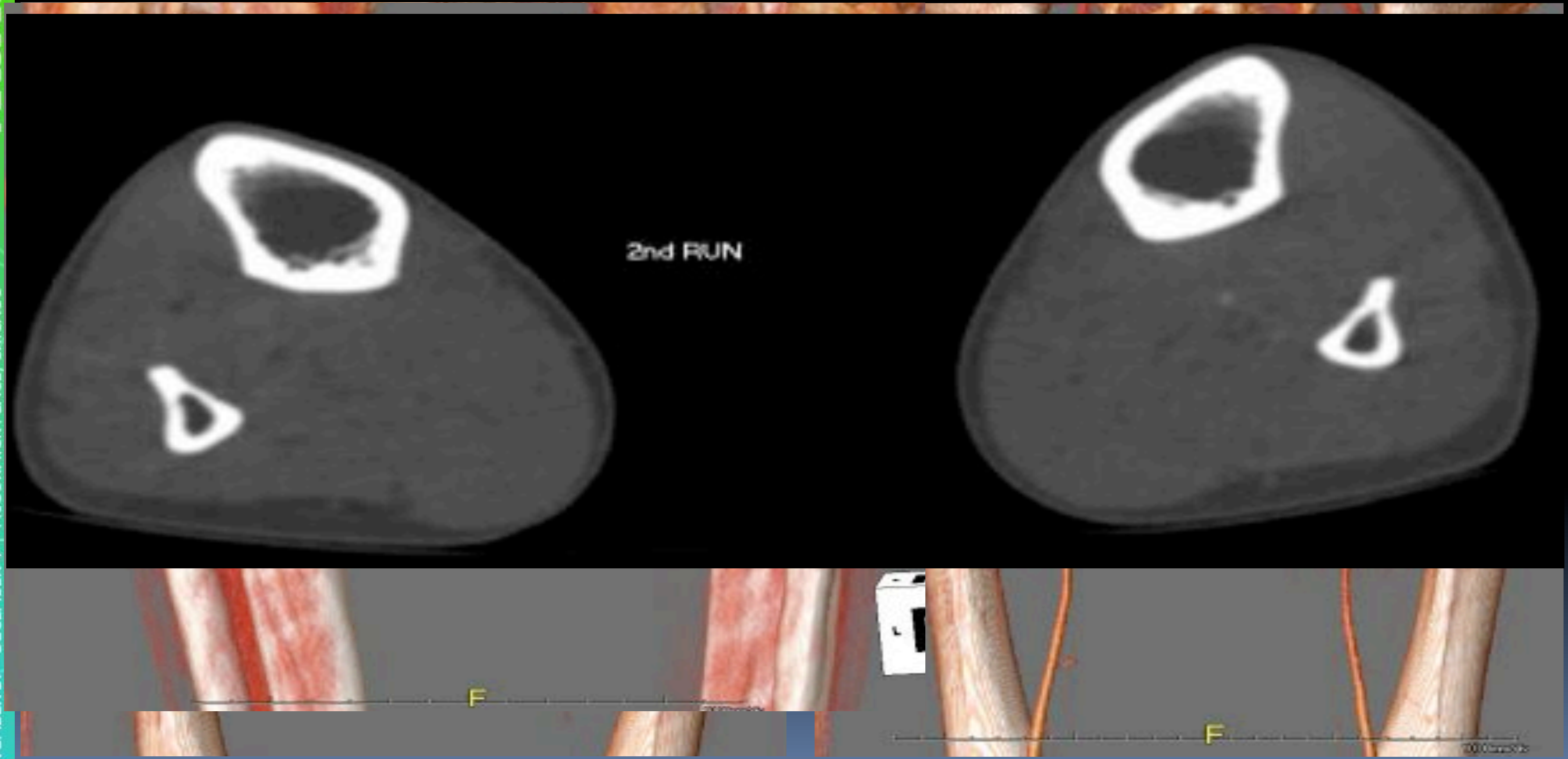
Detector Configuration (mm)	TI / 360° (mm)	Table Speed (mm/s)	Scanning Time (s)
64×.63	55	92	11-14
64×.60	29	78	13-17

very fast
~85 mm/s

Speed considerations for $\geq$64 slice CTA

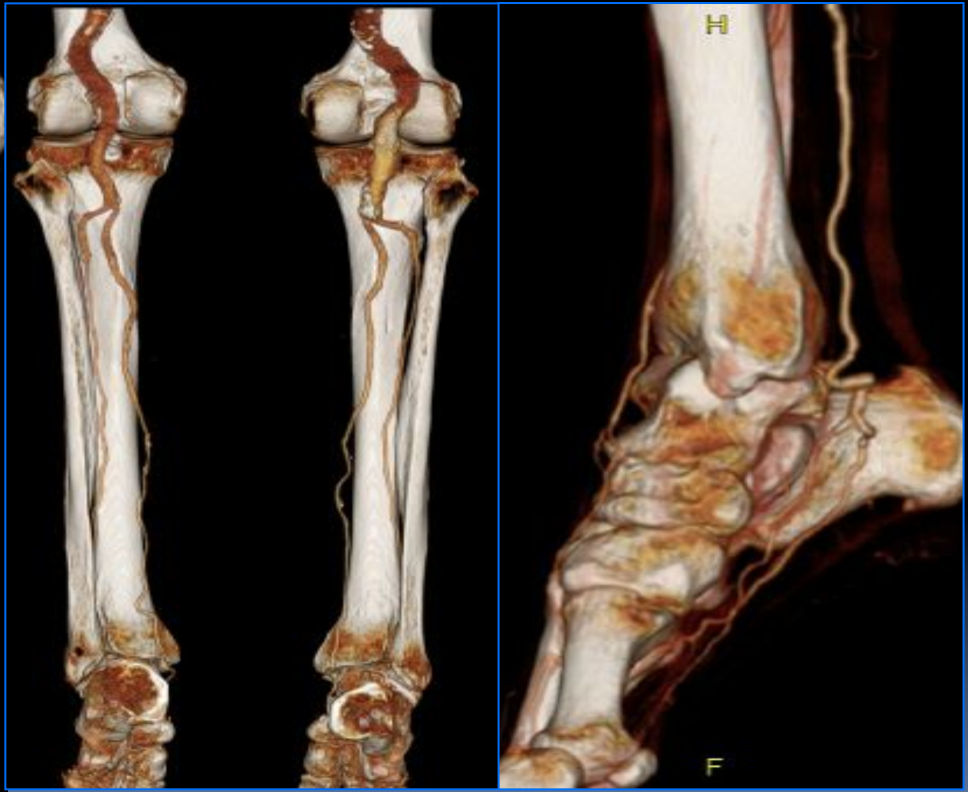
- Outrunning Bolus
- Delayed filling of distal arteries

Free-Flap Planning CTA

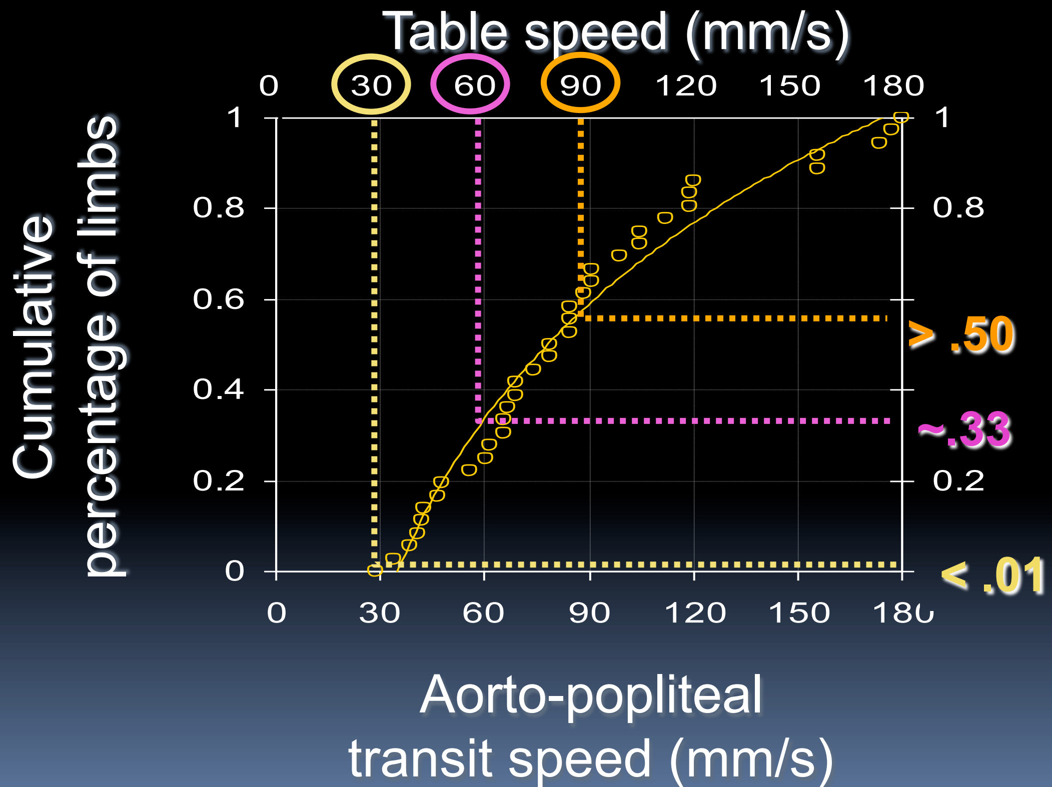


Arteriomegaly

preprogrammed,
optional 2nd acquisition



Peripheral arterial bolus propagation



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

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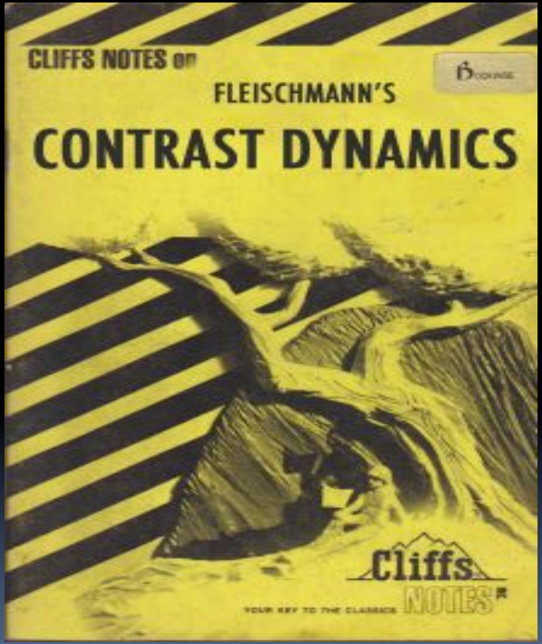
NOVEMBER 29 - DECEMBER 4 | McCORMICK PLACE, CHICAGO

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

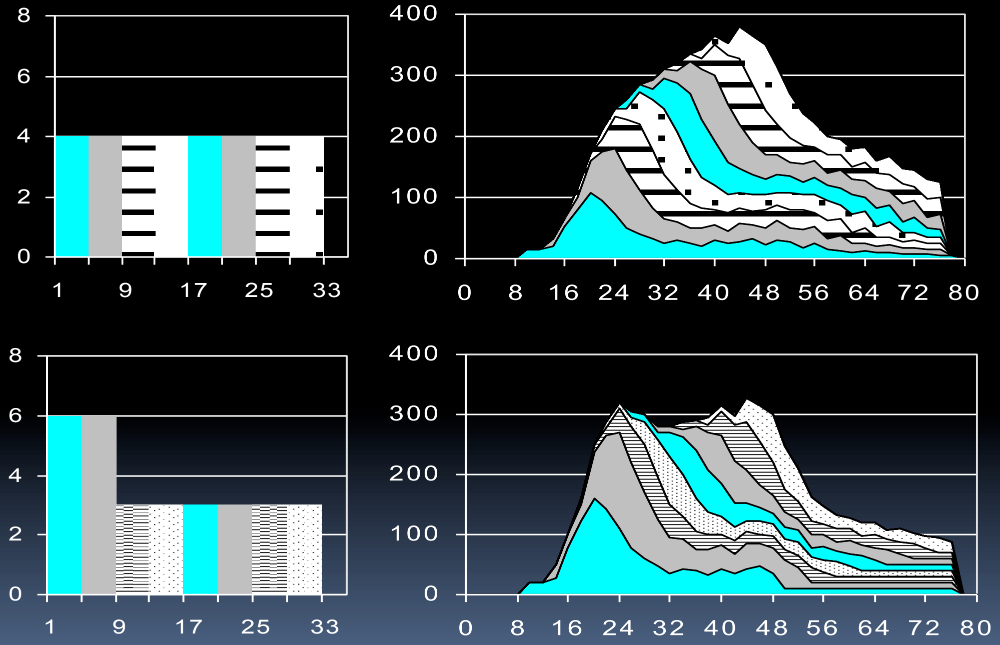
Fleischmann et al. JVIR 2006, 17(1) 3-26.

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)

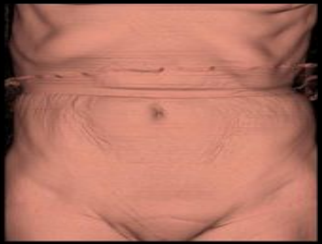
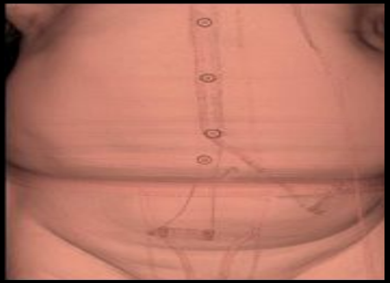


Biphasic Injection

Phase I
(surge phase)

Phase II
(continuing phase)

Patient Factors

- Arterial enhancement is <u>**inversely**</u> 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)

CTA Reconstruction

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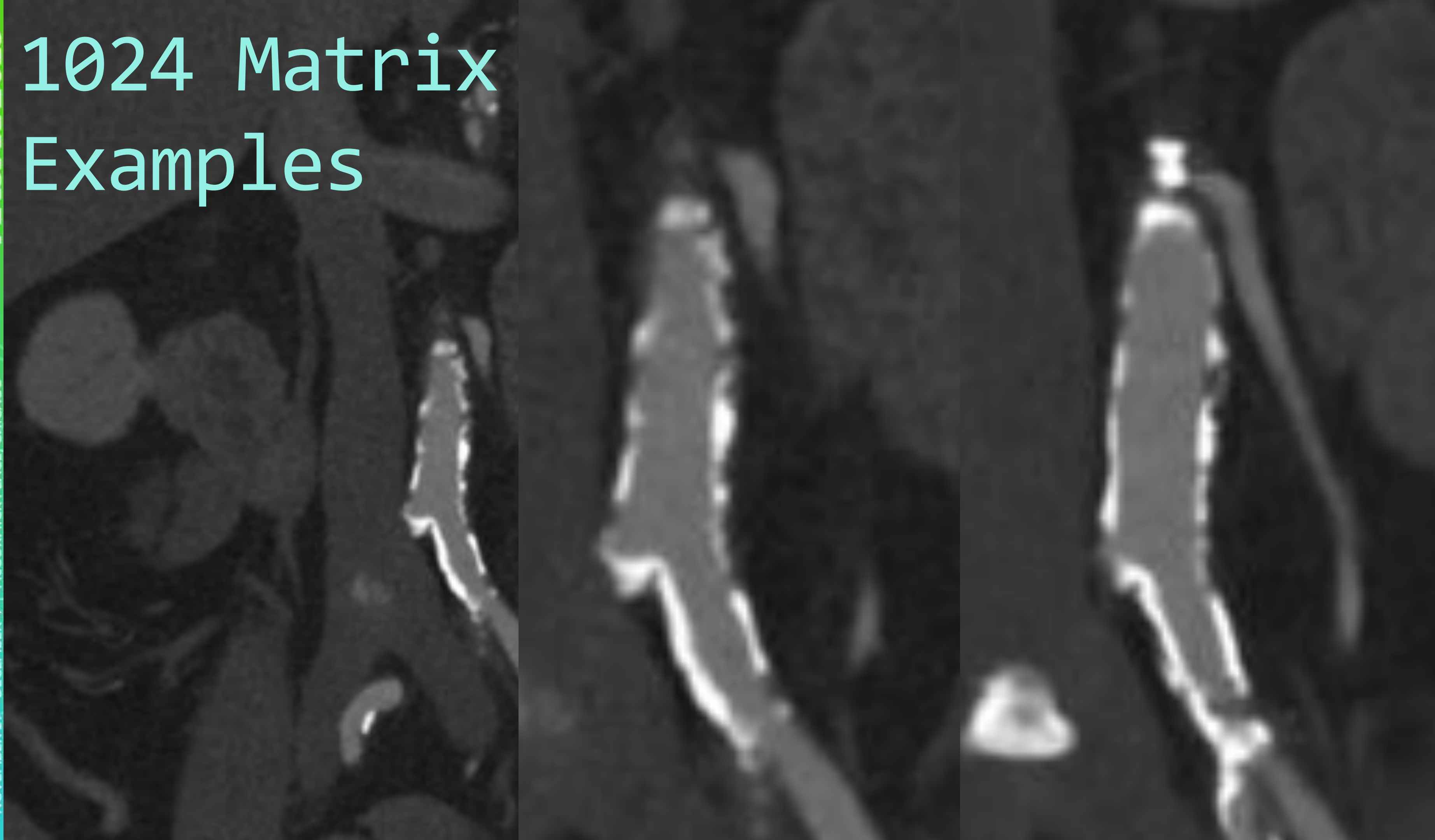
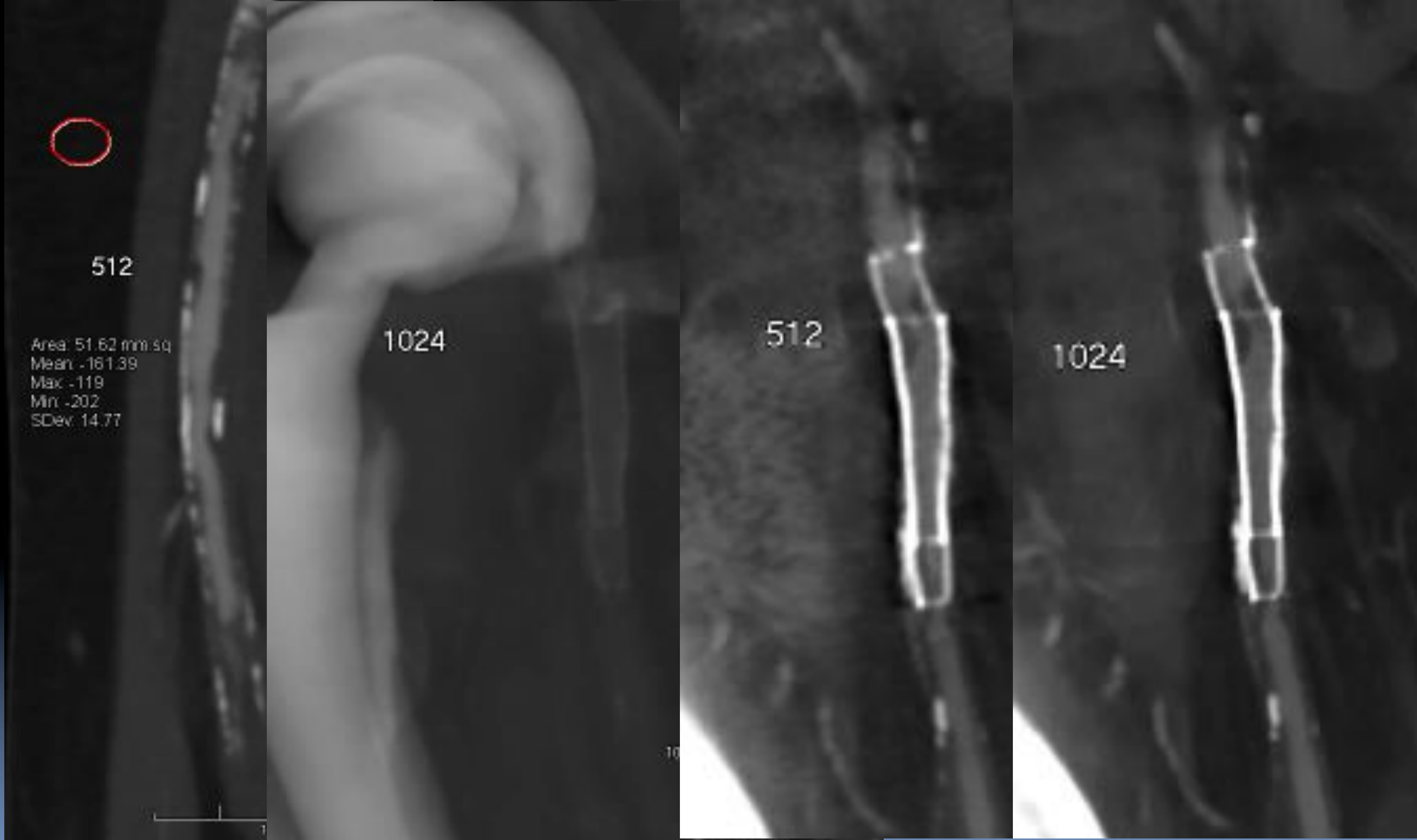
CTA Reconstruction and Interpretation

- 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**.

1024 Matrix Examples




512
Area: 51.62 mm.sq
Mean: -161.39
Max: -119
Min: -202
SDev: 14.77
1024
512
1024

Efficacy of LE CTA in PAD

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PAD Classification

	Fontaine Stage		Rutherford Classification
I.C.	I	Asymptomatic	0
I.C.	IIa	Mild Claudication (>200m walk)	1
I.C.	IIb	Moderate to Severe Claudication (<200m walk)	2 (moderate) 3 (severe)
CLI	III	Ischemic Rest Pain	4
CLI	IV	Ulceration or Gangrene	5 (minor tissue loss) 6 (major tissue loss)

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)

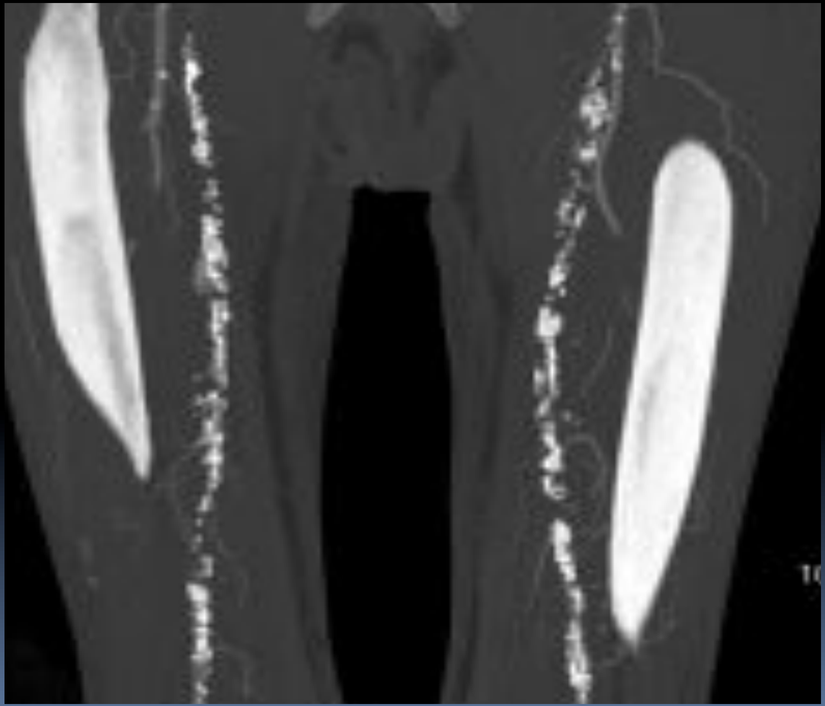
Met R et al. JAMA 2009;301:415-424

Diagnostic Performance: 64-slice CTA

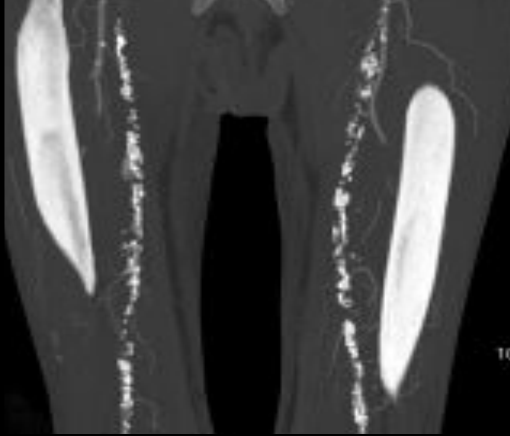
- Symptomatic PAD: 242 pts, 7420 segments
- CTA and DSA performed
- For >70% stenosis:
  - SENS/SPEC 96%   PPV 98%   NPV 99%
  - No sig difference vs DSA findings
  - Results similar in Ca++ vs. Non-Ca++ lesions

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

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 - Initial:
  - 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

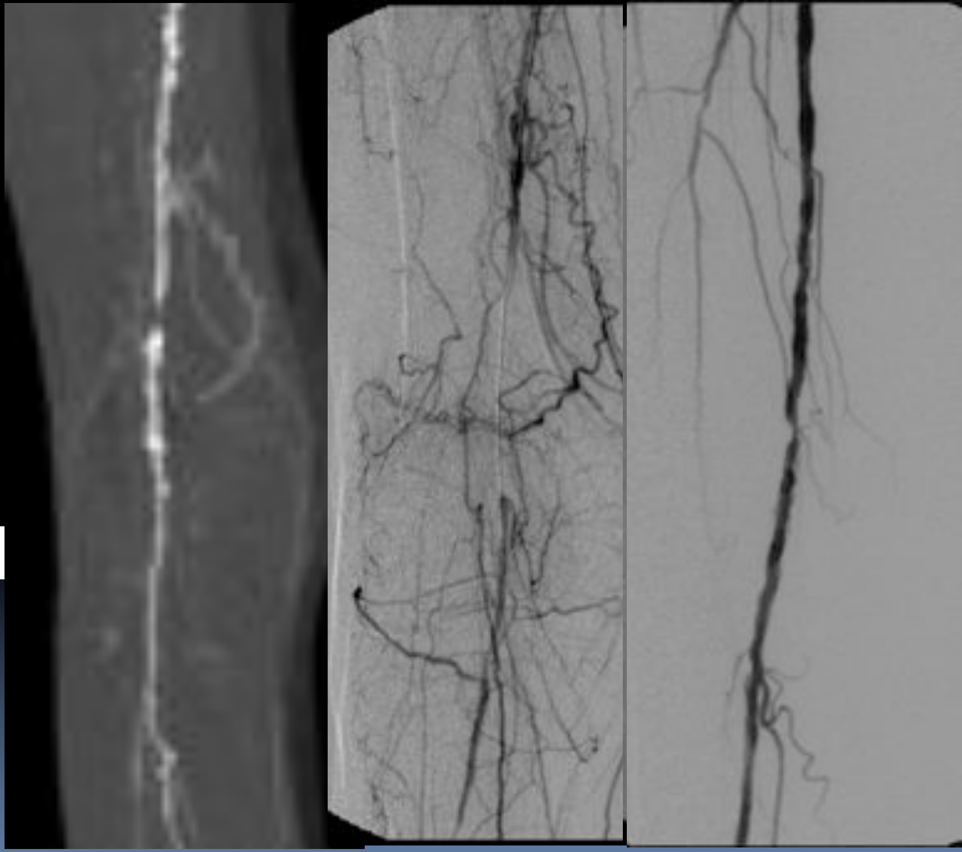
Sommer Eur. Radiol (2010) 20: 2876-2881

Clinical Utility of LE CTA in PAD

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

Intermittant Claudication (IC)

- Only ¼ progress clinically
- Amputation uncommon (unless diabetic)
- More likely ilio-femoral than trifurcation dz



Management of Intermittent Claudication by CTA

- 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

Critical Limb Ischemia (CLI)

- Duration > 2 weeks
- rest pain, tissue loss, ulcers, gangrene (TASC II)
  - Fontaine III / IV
- Higher incidence DM, trifurcation disease, comorbidities than IC

CTA assessment in 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 $\geq$ 50% stenosis:**
  - **Sens 99% Spec 98% Acc: 98%**

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

Management Decisions in 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

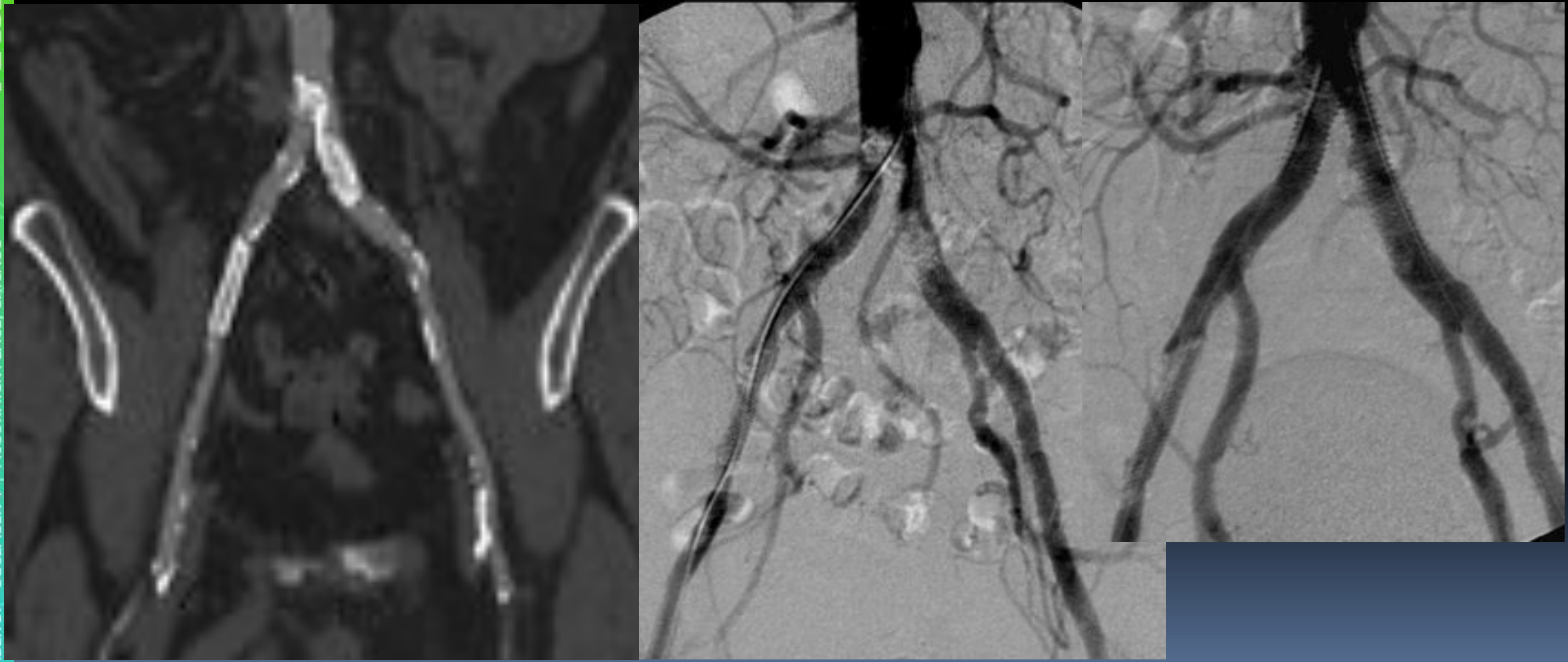
Schernthaner R, et al. AJR 2009; 192: 1416-1424

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 <u>in all but ONE</u>

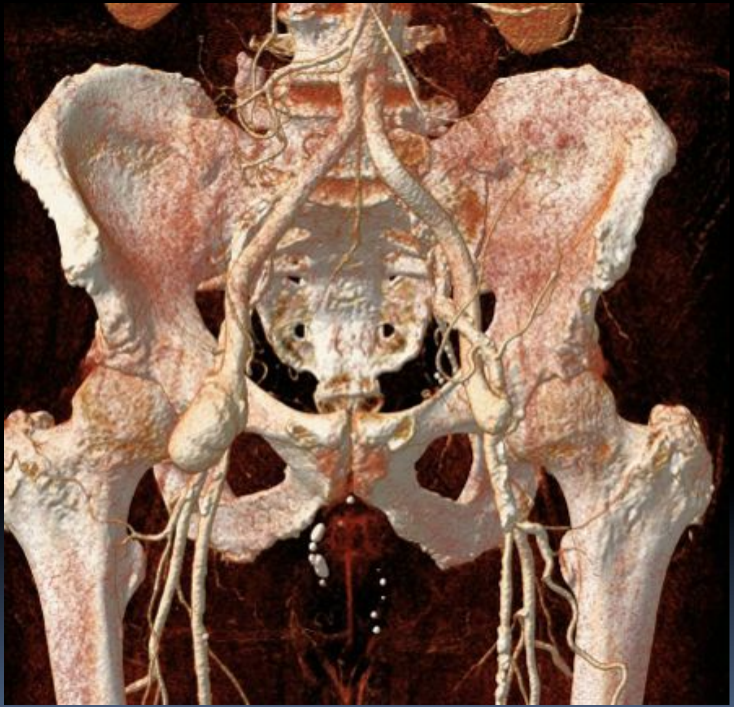
Napoli A. Radiology. 2011 Dec 1;261(3):976–86.

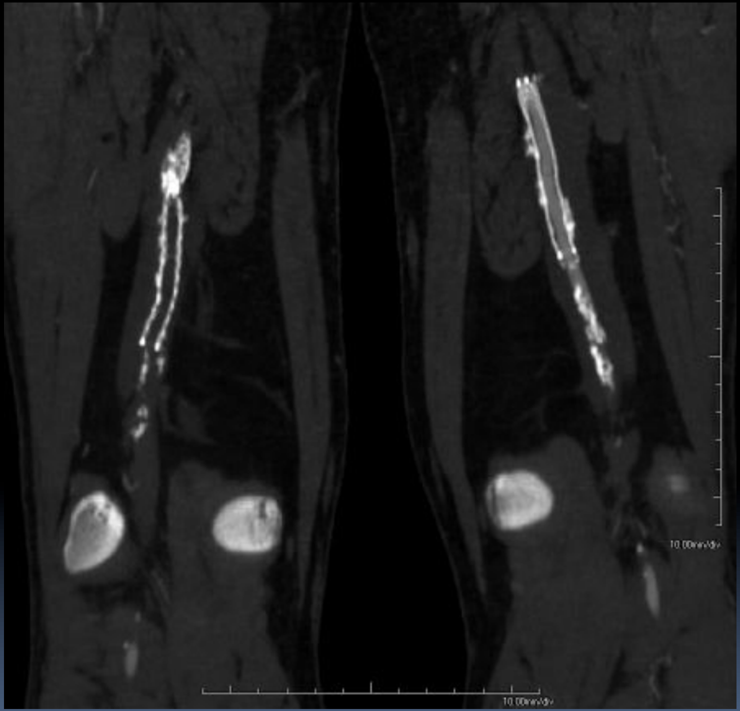
Buttock Claudication – Calcified Aorto-iliac Disease



Chang et al. JVIR. 2011 Aug 1;22(8):1131–1.

Post-TX Assessment by CTA





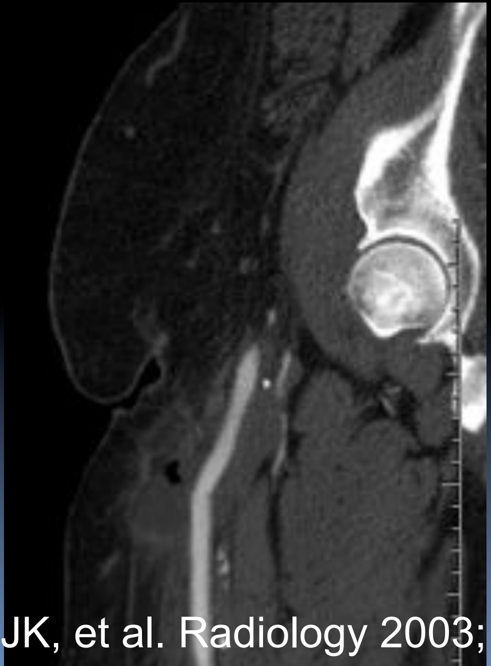
CTA for stent assessment

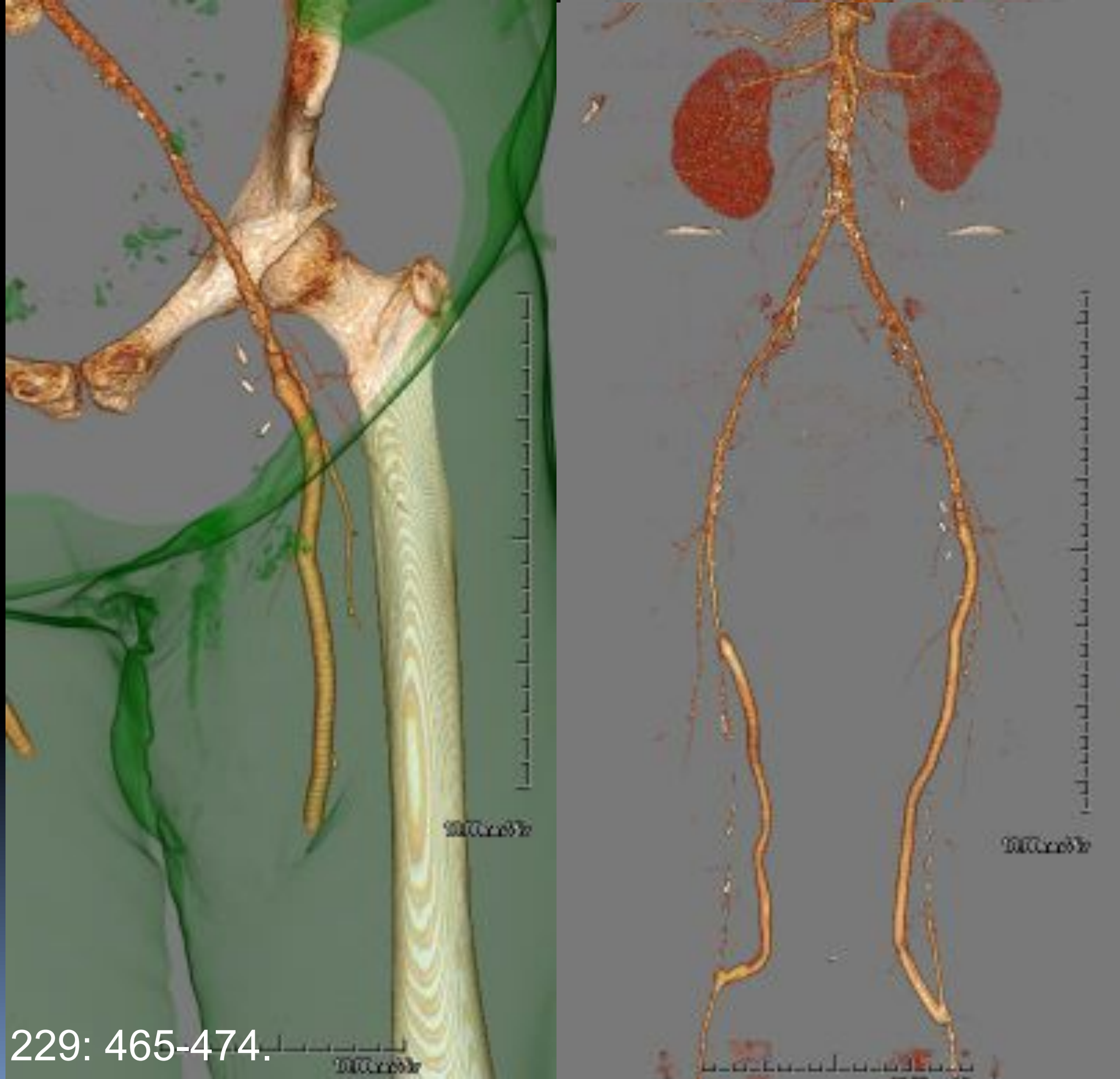
- Most stents assessable (76%) by CTA
  - Gold / platinum markers
  - Motion
  - Strecker stent (Tantalum): Increased luminal density [2]
- If evaluable, sens/spec ~ 95% for significant in-stent restenosis (vs. DSA)

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

CTA for assessment of complications

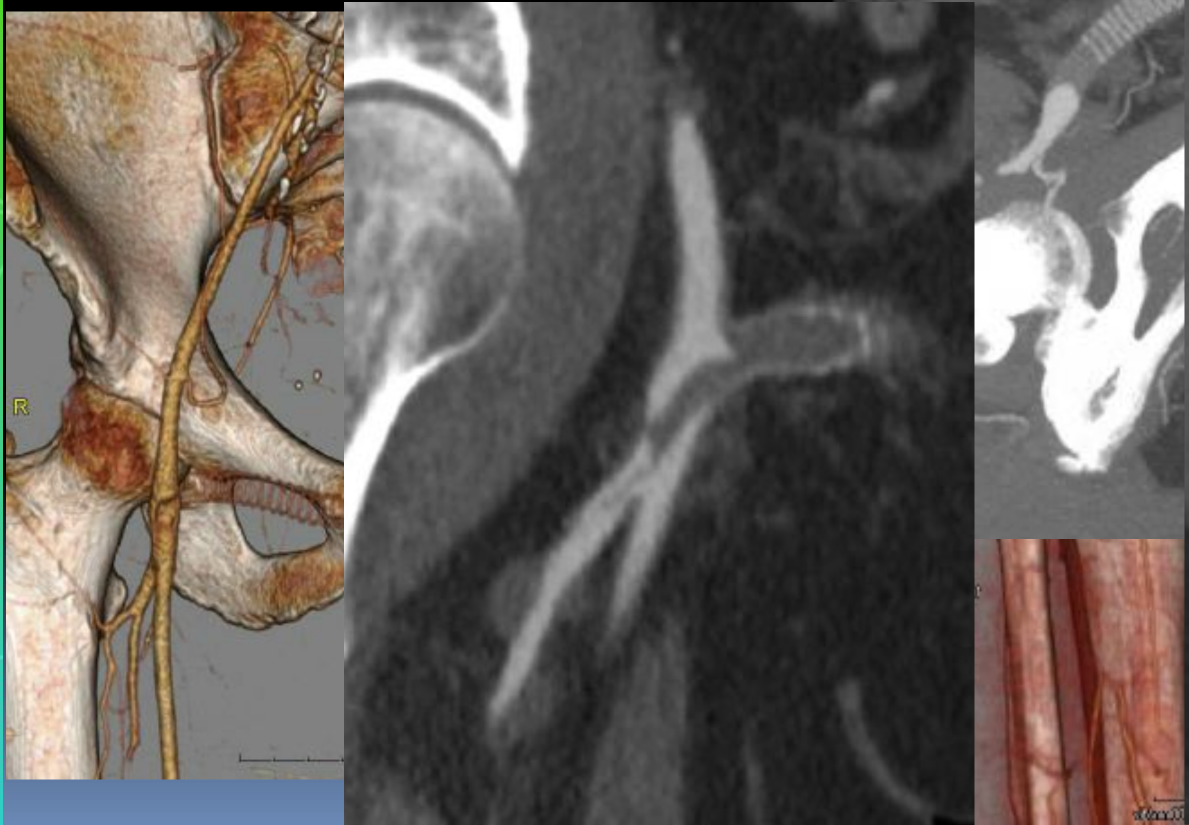
CTA for assessment of complications

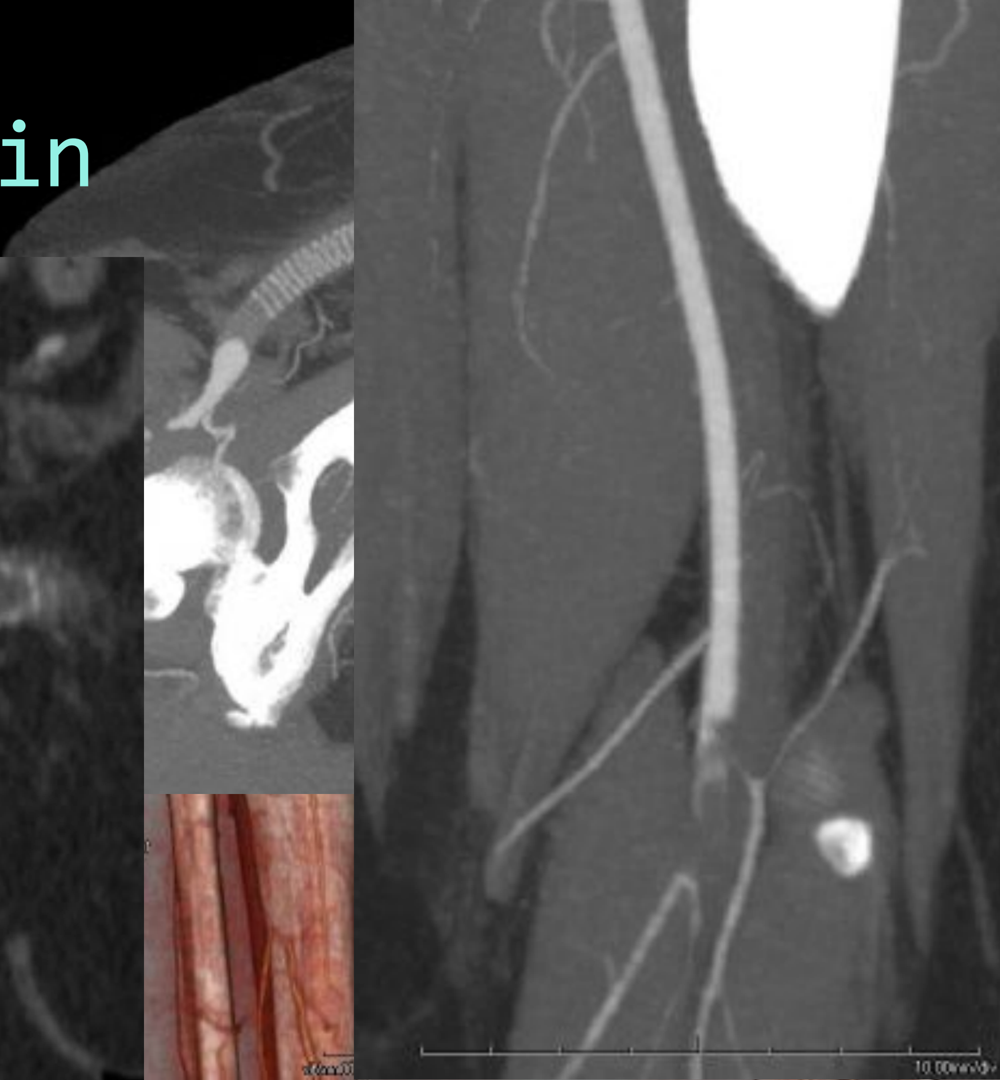




Willmann JK, et al. Radiology 2003; 229: 465-474.

Acute R leg pain





Cost-Effectiveness of CTA

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CTA as cost-effective care vs DSA

- 2005: Randomized, controlled trial: 4-DCT vs DSA[1]
  - Dx confidence slightly lower with CTA (calcifications)
  - CT cost-effective and provides sufficient information for Tx planning
  - DSA costs (564 Euro) greater than CTA (363)

[1] Kock, MC, et al. Radiology 2005. 237 (2) pp. 727-37

CTA as cost-effective care vs MRA

- 2005: RCT - 156 pts CTA vs MRA
- CTA/MRA utility similar
- CTA lower diagnostic costs /patient
  - Average costs: $199 vs $627
  - Difference from imaging test itself, not from additional procedures

Ouwendijk R, et al. Radiology 2005: 236: 1094-1103

CTA as cost-effective care (vs. US and MRA)

- 2008: DIPAD Trial (Multicenter RCT)
- 514 PAD pts, randomized to Doppler/MRA/CTA
- CTA and MRA:
  - significantly higher diagnostic confidence
  - less additional imaging needed
- Total costs lower for CTA

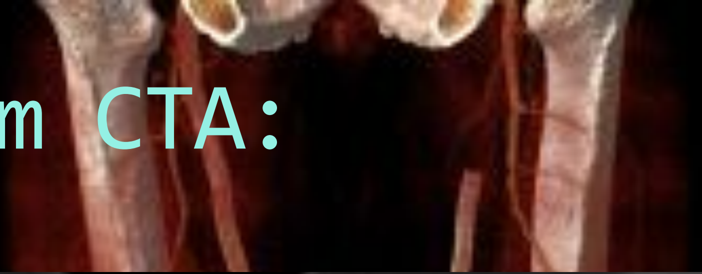
Ouwendijk R, et al. AJR Am J Roentgenol. 2008;190:1349–1357

Integrating CTA into cost-effective care

- 2005: Randomized, controlled trial: 4-DCT vs DSA[1]
  - Dx confidence slightly lower with CTA (calcifications)
  - CT cost-effective and provides sufficient information for Tx planning
  - DSA costs (564+/- 210) greater than CTA (363 +/- 273)
- 2007: Correct TX recommendations for I.C.[2]
- 2009: Correct TX recommendations for CLI [3]

[1] Kock, MC, et al. Radiology 2005. 237 (2) pp. 727-37
[2] Schernthaner, R, et al. AJR 2007; 189:1215-1222
[3] Schernthaner, R, et al. AJR 2009; 192:1416-1424

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 $\leq$ 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

- LE CTA is an accurate and cost-effective tool for assessment of various forms of peripheral arterial disease
- Implementation of integrated CM/ scan protocol will improve consistency
- Clinical integration and uses will continue to expand

Thanks for your Attention!

- Special thanks to.....

  Dominik Fleischmann, MD

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