Richard L. Hallett, MD

Chief, Cardiovascular Imaging
Northwest Radiology Network
Indianapolis, IN

Clinical Assistant Professor – Radiology
Stanford University
Stanford, CA

FUNCTIONAL VASCULAR IMAGING OF ATHLETES

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xraydoc97@yahoo.com

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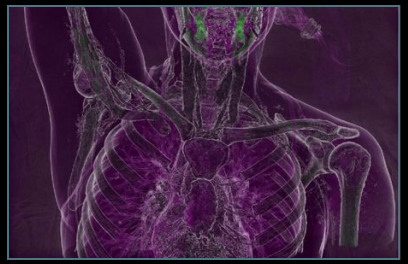
Learning Objectives

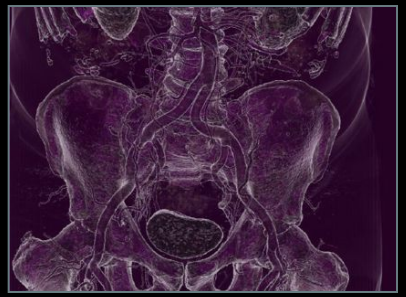
- Identify anatomic and functional lesions that predispose to vascular entrapment and fibrotic syndromes in athletes.
- Describe methods to assess vascular entrapment and fibrotic syndromes using dynamic, functionally challenged CTA and MRA.
- Describe the imaging findings for diagnosis.

What is your experience with functional (dynamic) cardiovascular imaging?

A. None
B. A little- once or twice
C. We perform these exams occasionally
D. Extensive experience
E. I do not know what functional imaging means

Vascular Diseases in Athletes





- Upper Extremity
  - Thoracic Outlet Syndrome (TOS)
- Pelvis
  - Iliac Endofibrosis
- Lower Extremity
  - Popliteal Entrapment Syndrome (PAES)

Background…….

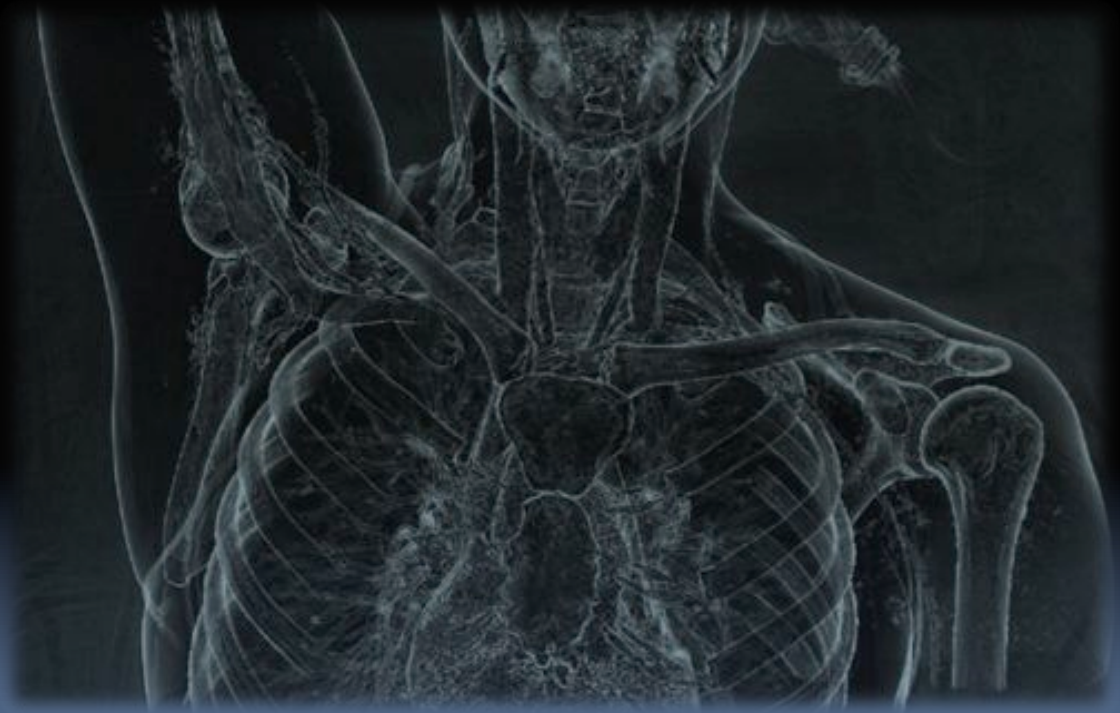
DYNAMIC EVALUATION IS IMPORTANT !!

- Vascular diseases are easily overlooked in athletes
- Thorough vascular H&P needed
- Deciding WHEN (or IF) to image vascular entrapment syndromes requires clinical judgment and multi-specialty coordination!!

Dynamic Cross-Sectional Imaging

- **Principle:** simulate the predisposing motion / position and assess vascular response
  - "Stress" and "Relaxed" Imaging
  - Vary timing to assess arteries / veins

- Thoracic Outlet Syndrome (TOS)



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The most common anatomic location for vascular thoracic outlet syndrome is

A. Costo-clavicular space
B. Retro-pectoralis minor space
C. Interscalene Triangle
D. Coraco-clavicular space

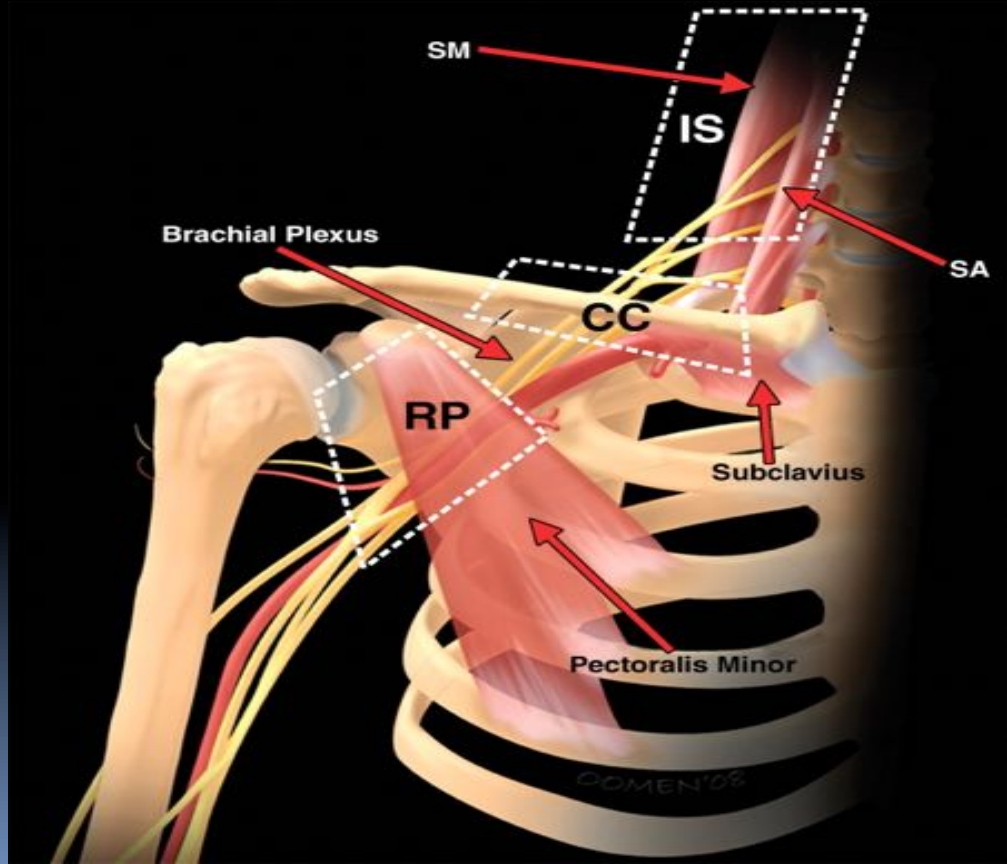
Linda D D et al. Radiographics 2010;30:1373-1400

Thoracic Outlet Syndrome (TOS)

- Symptomatic compression/entrapment of neurovascular structures by bone and/or soft tissue as they pass through the cervicoaxillary canal
- 90% Neurogenic (PT, postural Tx, NSAIDs)
- 10% Vascular
    - Venous > Arterial

Components of Cervico-Axillary Canal

- Interscalene Triangle: #1 site of compression
- Costoclavicular Space: #1 site for vascular TOS
- Retro-pectoralis minor space: #1 site for masses



Linda D D et al. Radiographics 2010;30:1373-1400

The most common anatomic location for vascular thoracic outlet syndrome is

A. Costo-clavicular space **CORRECT ANSWER**
B. Retro-pectoralis minor space
C. Interscalene Triangle
D. Coraco-clavicular space

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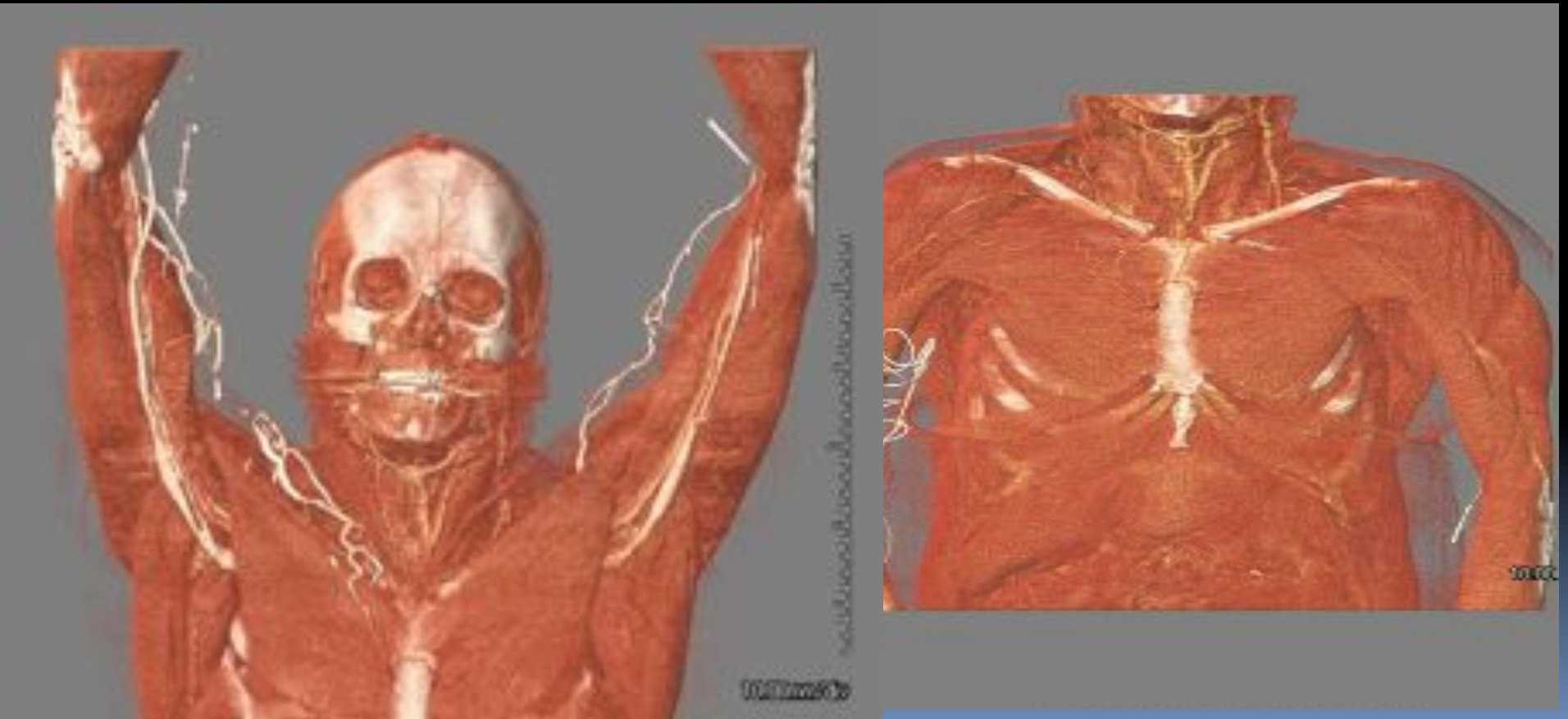
CTA for TOS: Combo Direct / Indirect CTA

- Ipsilateral IV, arm over head w/ palm taped up
- 120 mL full-strength @ 4ml/s
- Chase: 100 mL dilute (10%) contrast @2.5 ml/s
  - Can inject contralateral arm at same time (dilute)
- 65 sec empiric delay, scan caudo-cranial
- Arm down, immediate re-scan cranio-caudal
- **Volumetric Review**

Bilateral Direct / Indirect CTA

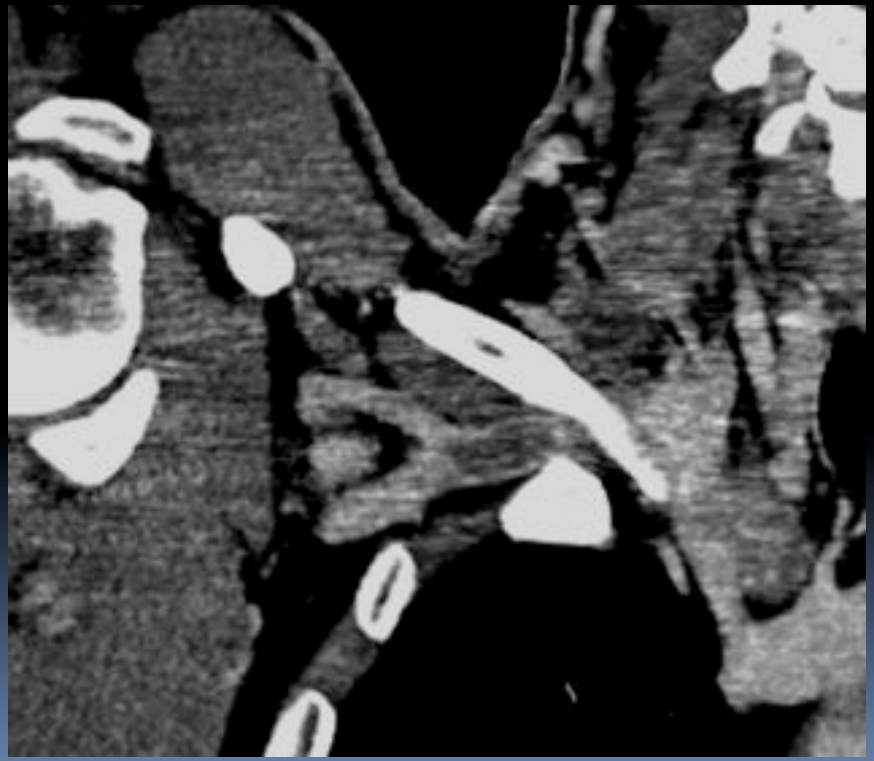


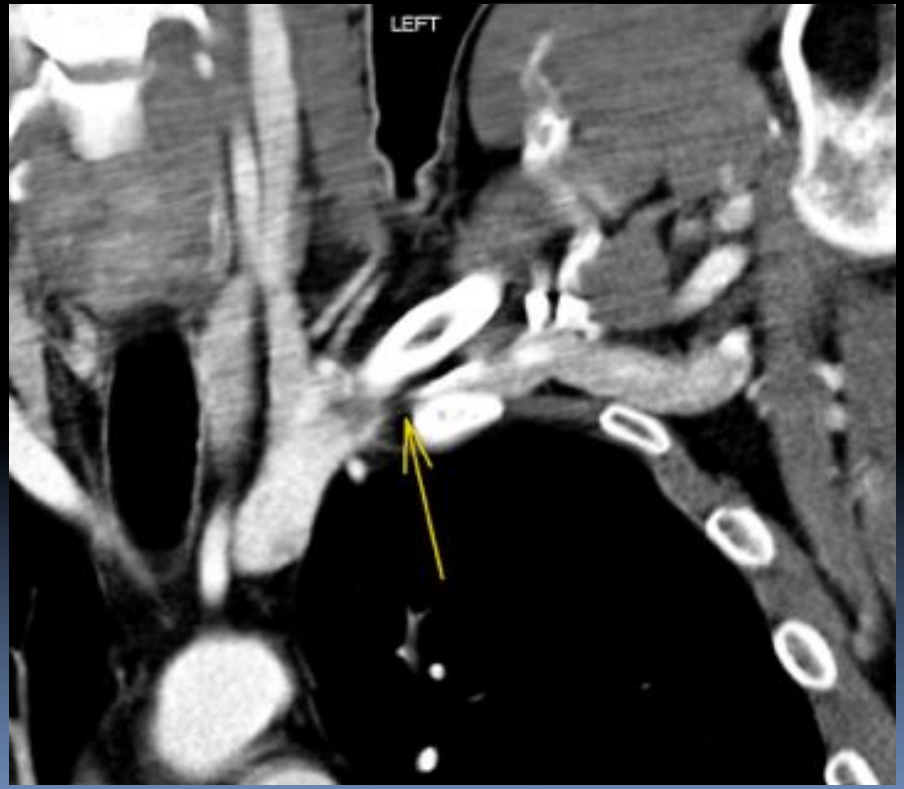
Venous TOS: "Effort Thrombosis"

- Paget-Schroetter syndrome (PSS)
- AKA axillo-subclavian venous thrombosis
- "Overhead" athletes
- PE in up to 1/3!! *
- Post-thrombotic syndrome (later)

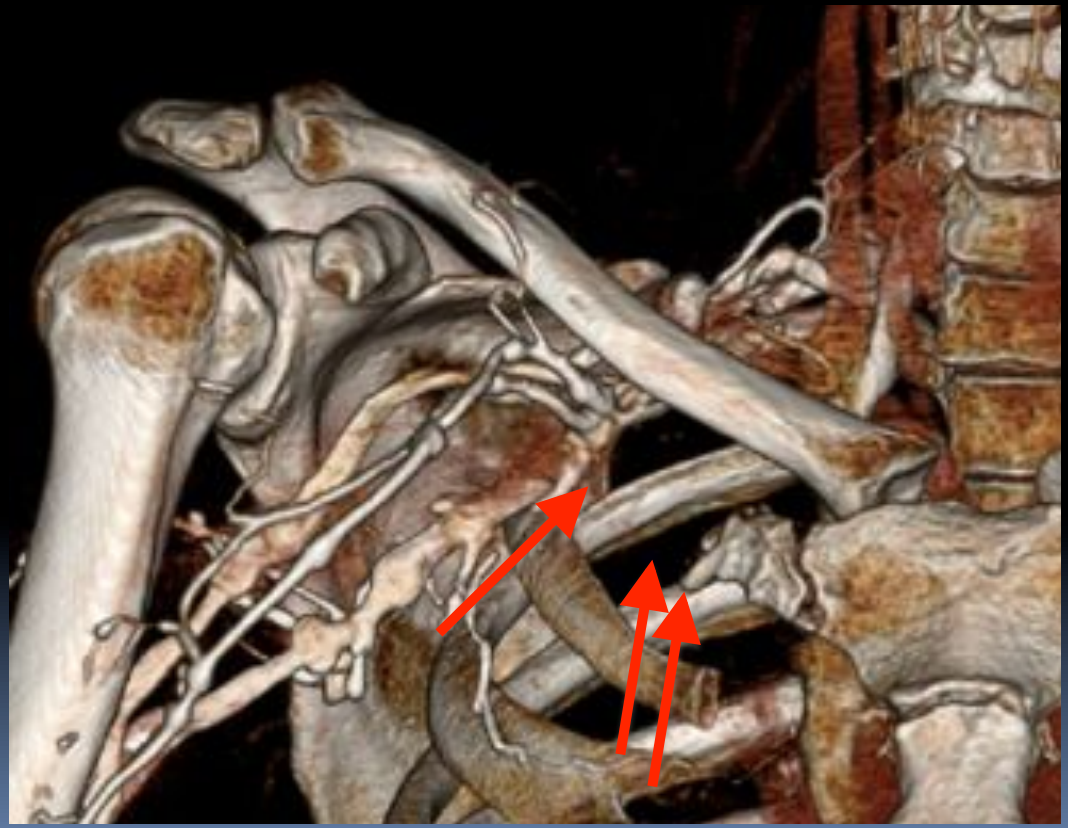
* Perlowski AA. Vasc Med (2010) vol. 15 (6) pp. 469-79

Effort Thrombosis:
36 YO weightlifter





Post-Op 1st rib resection



Arterial TOS

- "Overhead athletes"
- SX: Coolness, weakness, diffuse arm pain (ischemic neuritis)
- Cause: Repetitive compression injury
  - Anatomic predisposition (tight CCS)
  - Post-traumatic, bony callus
  - Scalene hypertrophy

Arterial and Venous TOS: 16 YO Volleyball Athlete

REST

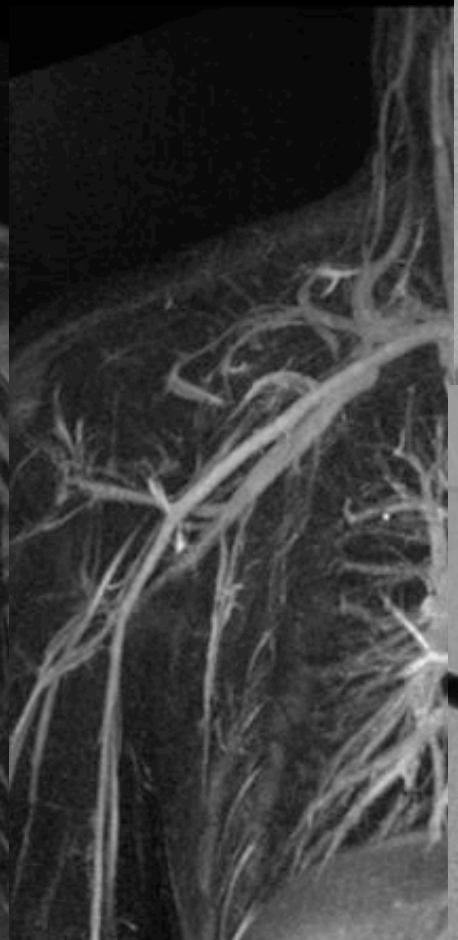
STRESS

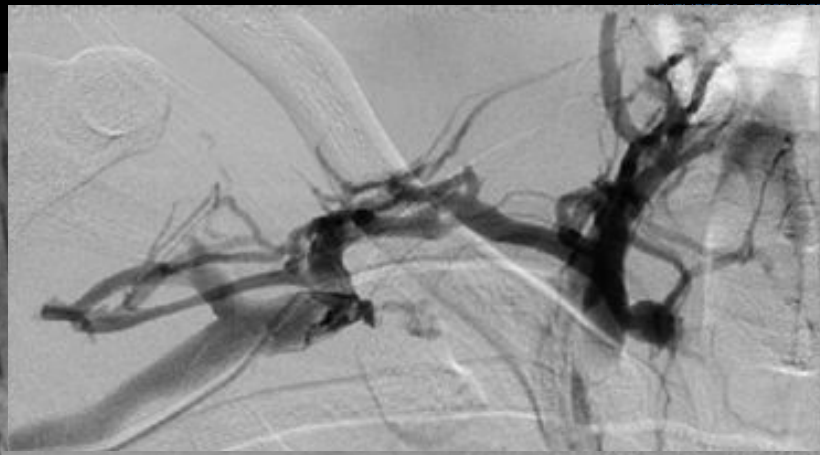
MRA for TOS: Blood Pool MRA

- Anatomic imaging: Oblique sag and cor T1/T2
- Relaxed and Challenged imaging:
  - Gadofosveset (blood pool agent)
  - Breath-hold FSPGR, ECG-gated, high resolution (1.8 mm ST, 448 x 448 matrix) CORONAL acquisition
    - Challenged: Arm Abducted
    - Relaxed: Arm Down

Arm UP

Arm DOWN





Iliac Endofibrosis

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Iliac endofibrosis is a(n):

A. Acute inflammatory vasculopathy
B. Early (accelerated) atherosclerotic process
C. Vasculitis related to HLA-B27 antibodies
D. Non-inflammatory, non-atherosclerotic disease

Lim CS, et al. Eur J Vasc Endovasc Surg 2009:38:180-6.

Flow limitations in the Athlete's pelvis

- Dynamic:
  - Elongated / tortuous vessels
  - Kinking with or w/o stenosis (elongation/ tethering)
  - compression (psoas hypertrophy, ligaments)
- Static: Iliac endofibrosis

Lim CS, et al., Eur J Vasc Endovasc Surg 2009:38:180-6.

Iliac Endofibrosis

- 90% of pts are cyclists
  - >10,000 km/yr or 150,000 km lifetime
  - Also: speed skaters, runners, wt lifters, XC skiers, and rugby players
- 90% external iliac artery
- Smooth, eccentric, non-calcified
- Pathology: intimal fibroplasia, medial hypertrophy, and adventitial hyperplasia. Involved segments universally free from atherosclerosis.

Lim CS, et al. Eur J Vasc Endovasc Surg 2009:38:180-6.

Iliac endofibrosis is a(n):

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B. Early (accelerated) atherosclerotic process
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D. Non-inflammatory, non-atherosclerotic disease **ANSWER**

Lim CS, et al. Eur J Vasc Endovasc Surg 2009:38:180-6.

Endofibrosis CTA: Imaging technique

- Two phases: relaxation and hip flexion
- Coverage ~ 40 cm
- Relaxation – 100 kVp, flexion – 120 kVp
- ~ 80 mL of IV contrast at 4 -5 mL/s for each phase (20 sec injection)
- Saline flush at same rate
- Scan time 10 - 12 sec
- Volumetric Review

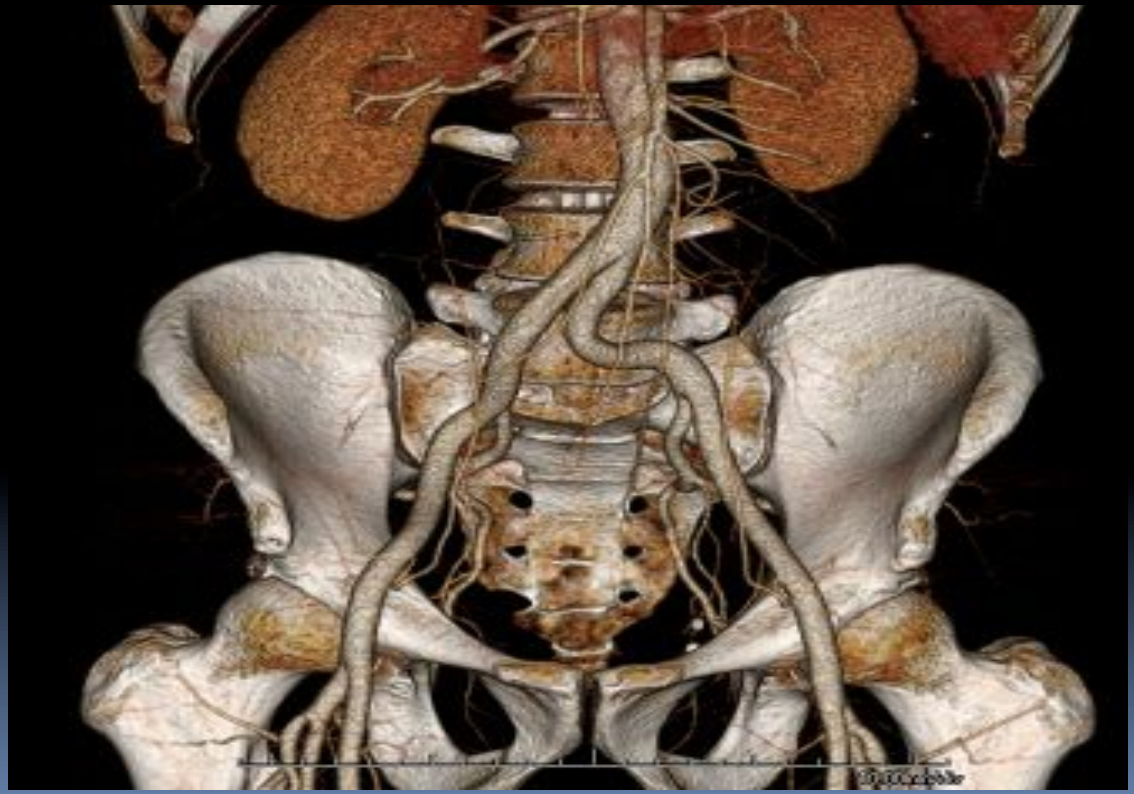
CTA: Positioning

- Simulate cycling position as closely as possible considering space within CT gantry (almost 90^{0})

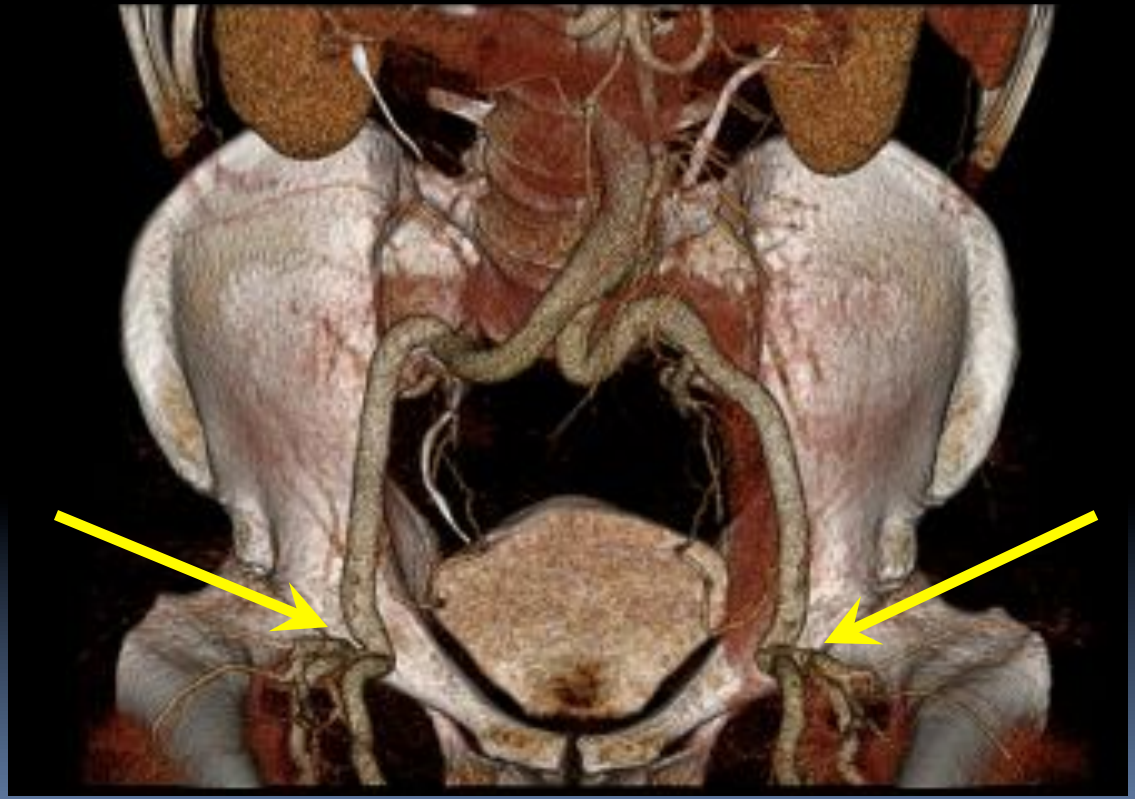
Case 1

- 45 yo avid cyclist
- Proximal thigh pain, cramping with exertion
- ABI drops with exertion

Supine, legs extended



Hip Dysplasia Flow Restriction



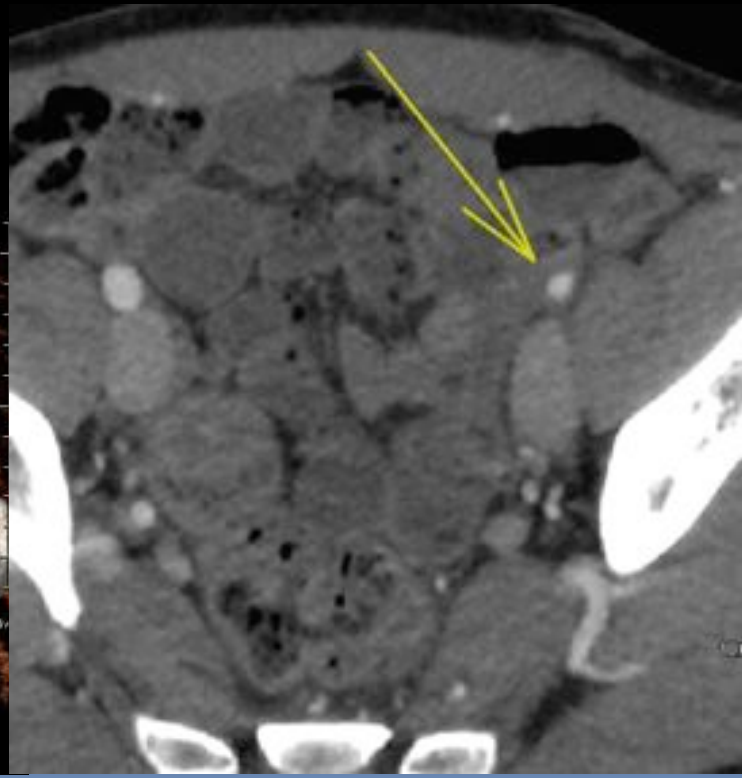
Case 2

- 26 yo elite female cyclist
- left thigh and buttock pain at high performance levels.

Case 2

NEUTRAL

FLEXION

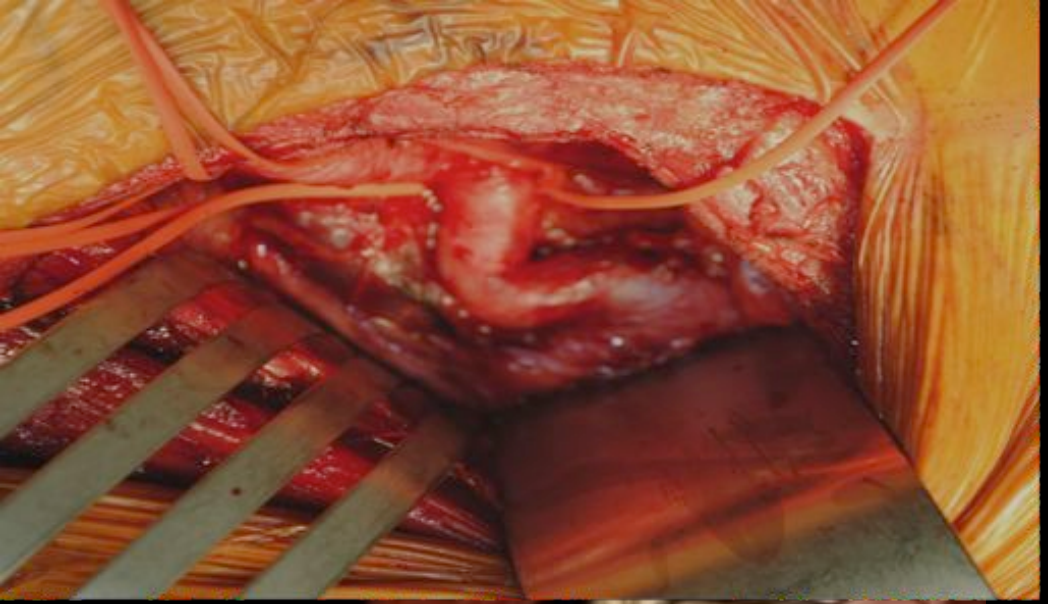


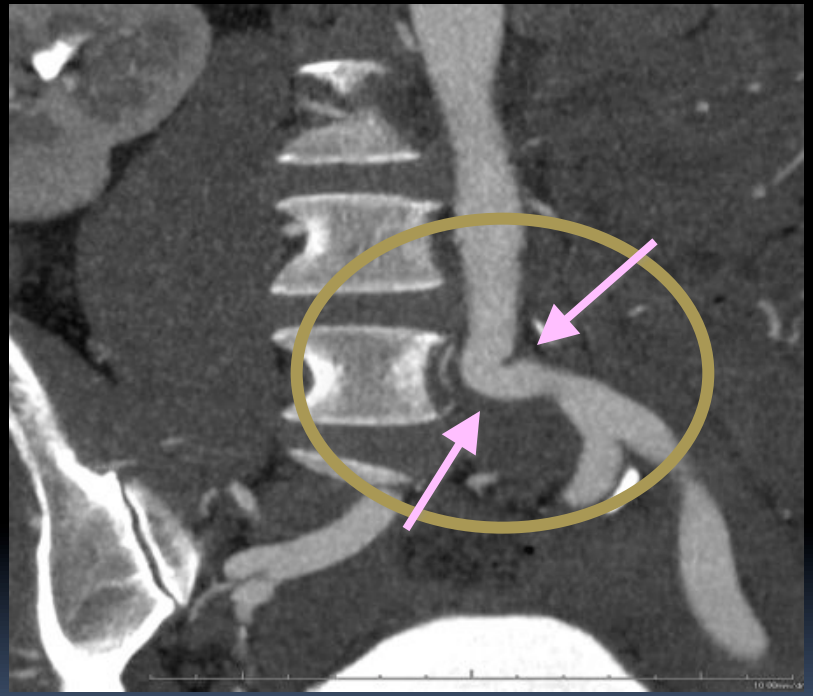
Case 3

- 49 yo avid cyclist x 30 yrs
- left thigh and buttock pain at high performance levels.
- Pain described as a “deep burn”

- ABI R/L: 1.3/1.2
- Exercise ABI R/L: 1.5/1.2

CTA at Rest





- Pathology: intimal thickening and fibrosis
- No inflammatory change

Endofibrosis MRA: Imag technique

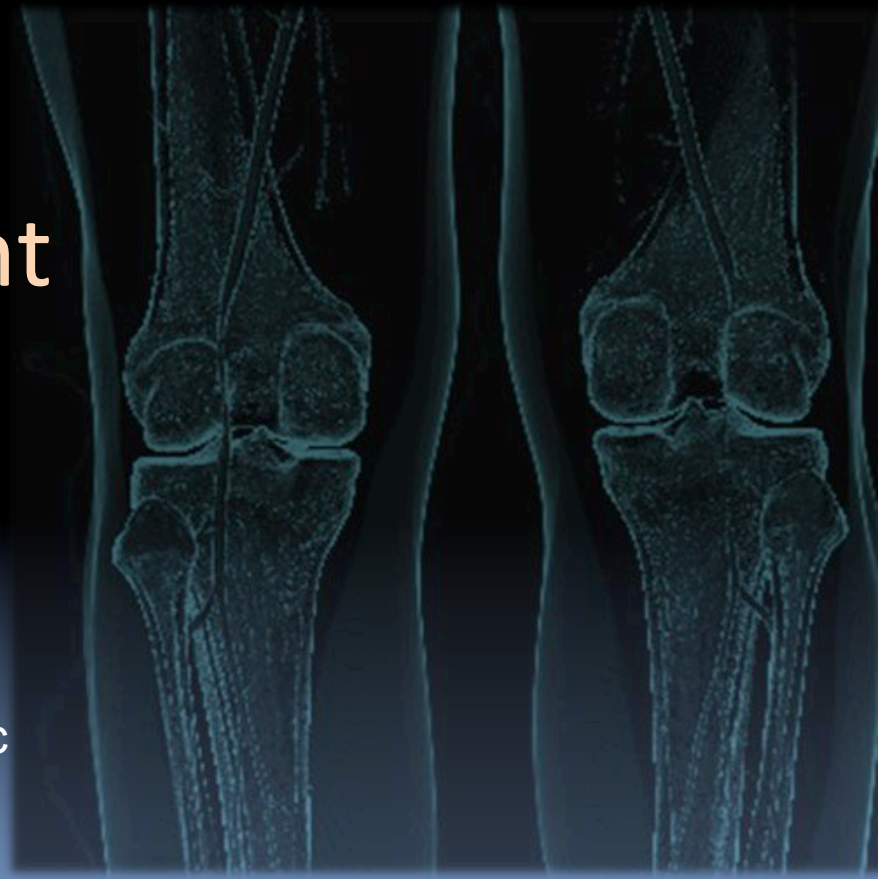
- Anatomic imaging – T1
- Arterial Phase FSPGR I
- Relaxed and Hip Flexio
  - Respiratory gated, steac
  - Near-Isotropic
  - Blood Pool contrast Age
- Volumetric Review

Naehle CP. J Am Coll Cardiol Img. 3 2010:504-513

Vascular Diseases in Athletes

- Lower Extremity

  Popliteal Entrapment Syndrome (PAES)



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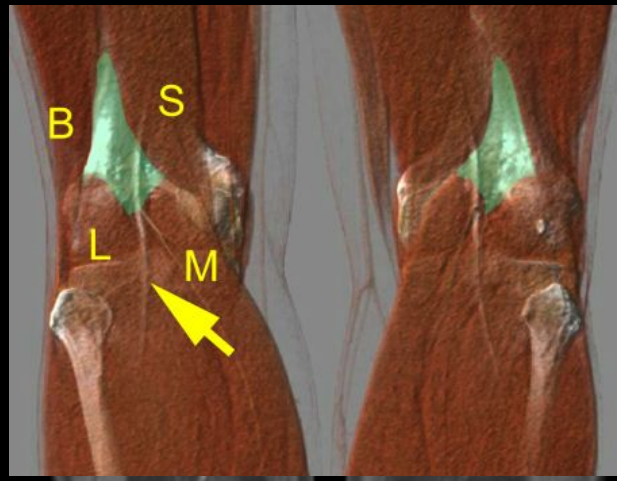
Most cases of Popliteal entrapment syndrome arise from:

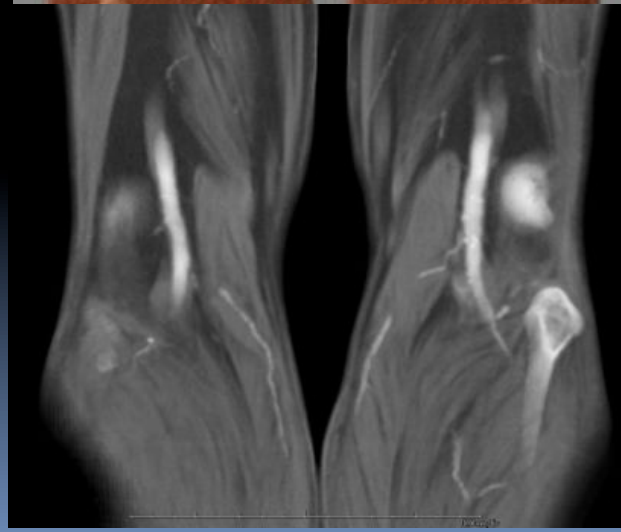
A. Chronic repetitive trauma to popliteal artery / vein
B. Embryologic conflict between muscles and vessels
C. Premature atherosclerotic disease
D. Chronic exertional compartment syndrome

Macedo TA, et al. Popliteal Artery Entrapment Syndrome: Role of Imaging in the Diagnosis. American Journal of Roentgenology. 2003 Nov;181(5):1259–65.

Popliteal Space - Embryology

- *In utero*: competition between popliteal neurovascular bundle and migrating muscles (medial head gastrocnemius) for space
- If delayed or abnormal migration → **MHG too far lateral**
  - space is limited





Causes of Popliteal Entrapment

- Anatomic Compression
  - Abnormal popliteal artery course
  - Abnormal muscle (MHG)
  - Both
- "Functional" compression

Most cases of Popliteal entrapment syndrome arise from:

A. Chronic repetitive trauma to popliteal artery / vein
B. Embryologic conflict between muscles and vessels ANSWER
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Classification of PAES

Type	Anatomy
I	PA travels aberrantly, medial to normally positioned MHG
II	Anomalous lateral and inferior origin of MHG, PA displaced medially
III	Normal PA compressed by muscular slip or aberrant band from MHG
IV	PA deep in popliteal fossa, entrapment from aberrant band or popliteus muscle
V	Any type of entrapment **involving popliteal vein**
VI	"Functional" Entrapment

* Whelan TJ. In: Haimovici H, Ed. Vascular surgery: principles and techniques. New York: McGraw-Hill, 1984: 557-67

Functional Popliteal Entrapment (Type VI)

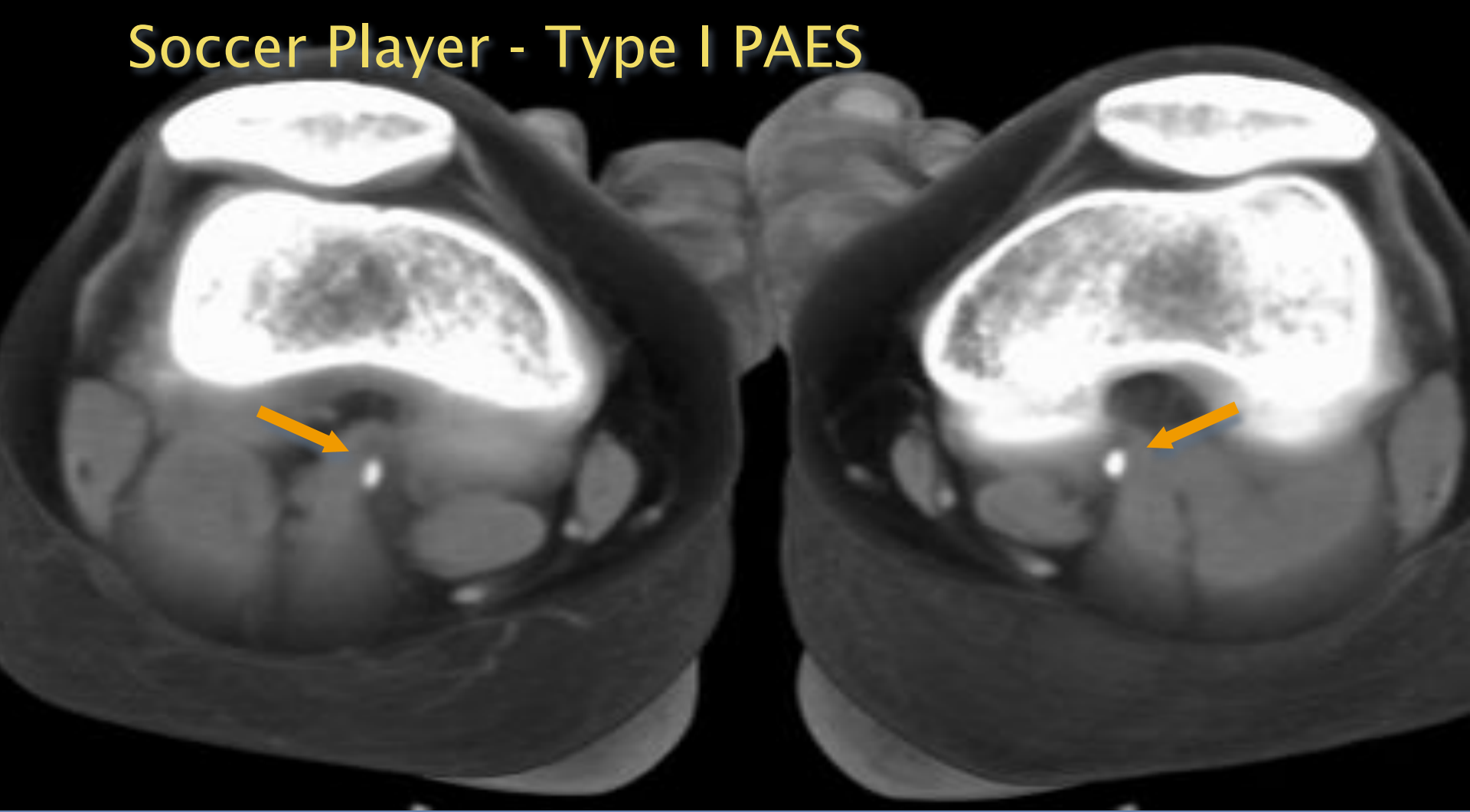
- Younger population, highly conditioned athletes
- Neurovascular compression by hypertrophic gastrocnemius +/- soleal sling
- Longer segment involvement (vs. anatomic PAES)
- Conservative Tx first, debulking if needed

PAES: CTA Imaging Technique

- 3 phases – relaxed, active plantar flexion, venous
  - Active plantar-flexion without bearing down (straps)
- ~ 80 mL of contrast (4mL/s) for 2 phases followed by saline flush at same rate
- Bolus track distal SFA
- Scan time: 12-15 sec on 64-MDCT
- Pulse oximeter on symptomatic large toe

PAES: CTA Imaging Technique

Soccer Player - Type I PAES

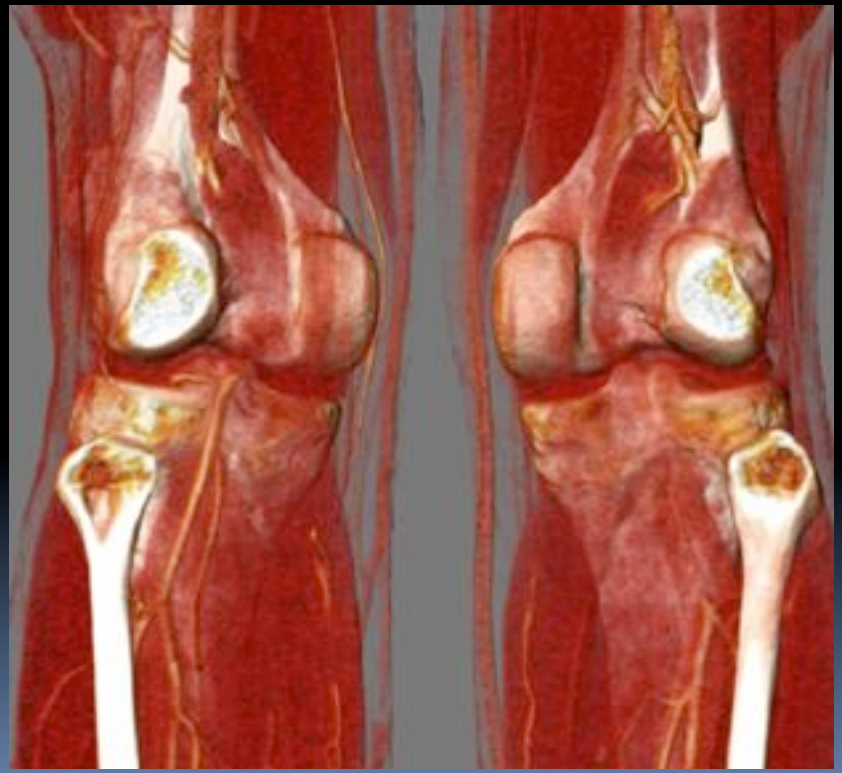


Type III PAES - Thrombosis of left popliteal artery

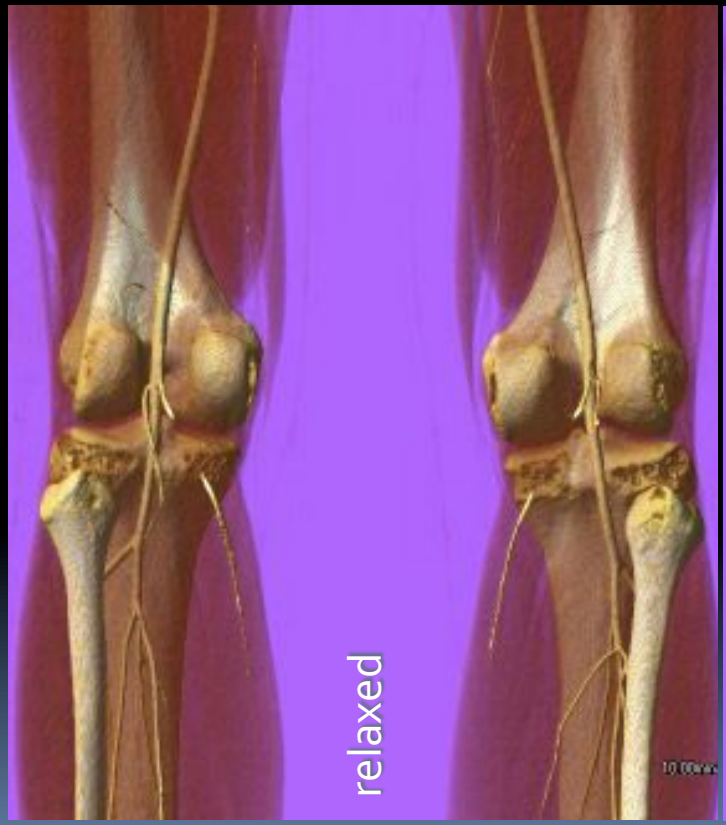
LEFT RIGHT

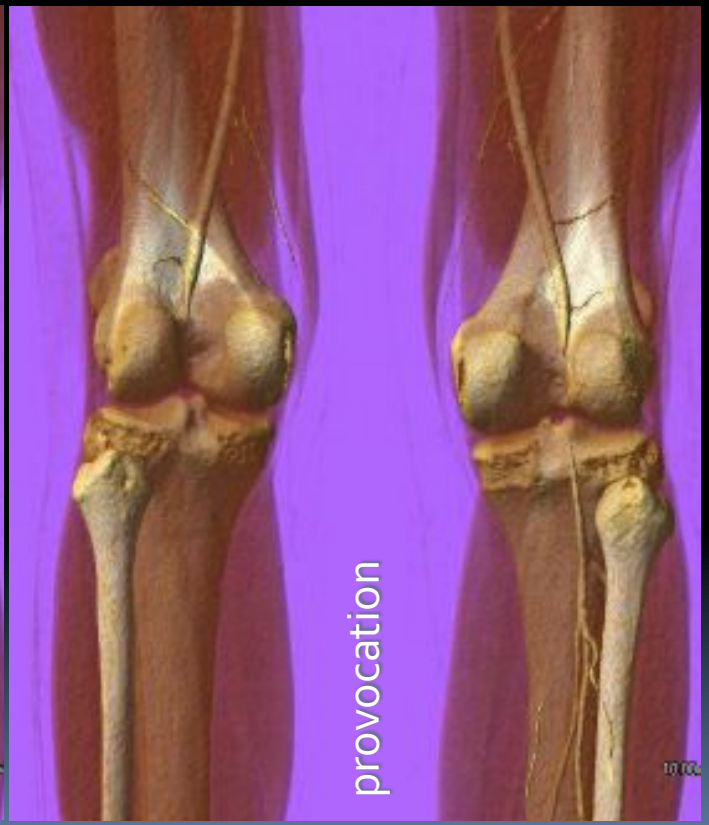
Relaxed –posterior view

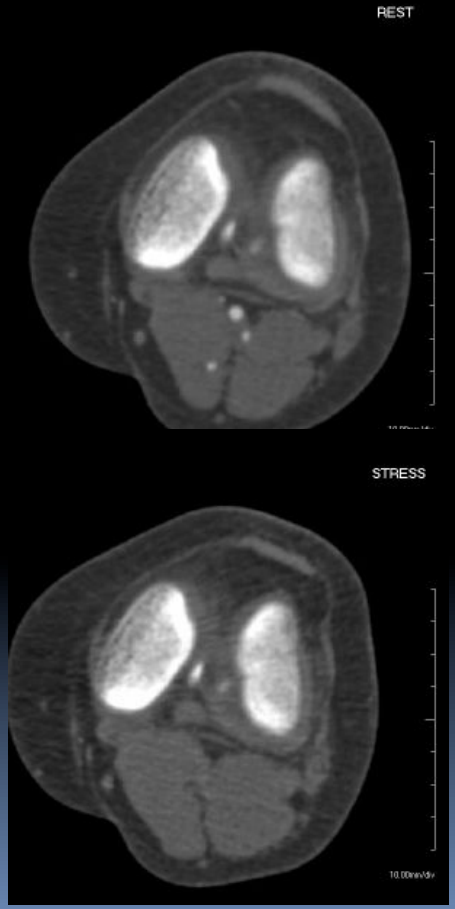
provocation



Functional (Type VI) PAES



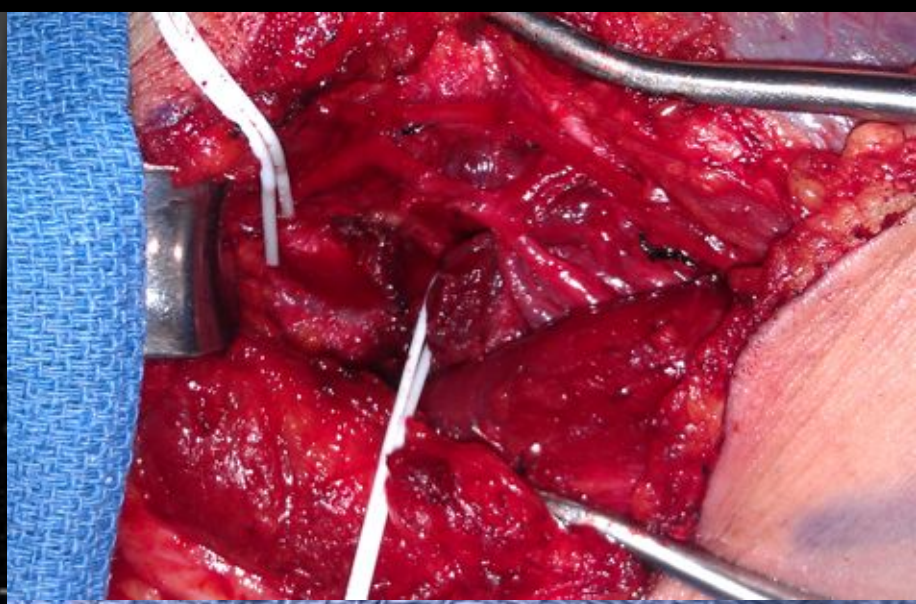




PAES: Challenged MRA technique

- Anatomic imaging (axial/coronal T1/T2)
- Challenged and Relaxed Acquisition (like CTA)
- blood pool agent gadofosveset
- Thin-slice Coronal (1.4mm) steady-state acquisition (576x576 matrix)
- 3D assessment


H
A



Conclusions

- Vascular diseases in athletes can be a significant source of disability and performance loss
- Functional imaging is important for accurate detection and characterization of vascular entrapment / stenotic syndromes
- CTA and MRA with functional techniques allow non-invasive assessment

Thanks for Your Attention !!

Special Thanks to:
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Joel Feldman, MD

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