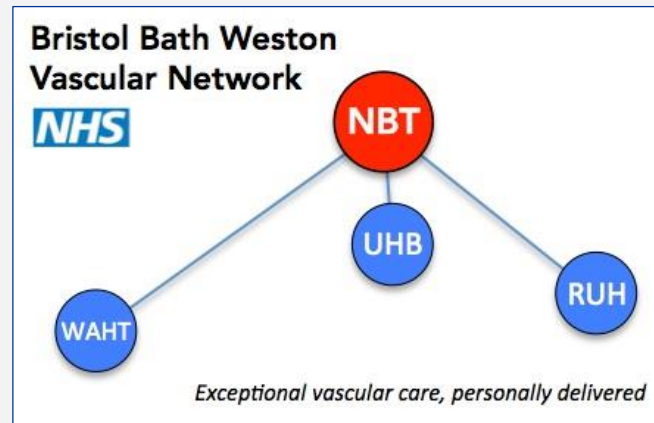


Regions of interest

Rob Hinchliffe
University of Bristol &
Bristol, Bath & Weston Vascular Network

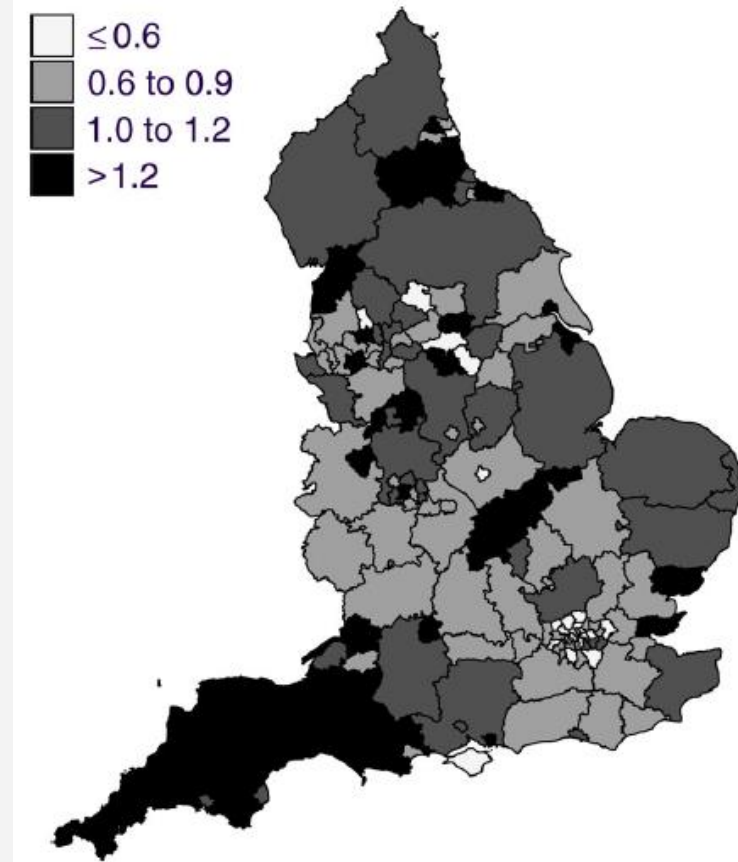


Overview

- Diabetic foot perfusion
- Popliteal entrapment
- Iliac endofibrosis

Diabetes and Amputations

- 8x variation
- Reasons unknown
- Variations in clinical practice
- Organisation / access care
- Standardisation of (vascular) care



Holman, Diabetologia. 2012;55:1919-25

PAD in Diabetes

- 5% adults with type 2 diabetes
- Common in DFU (70% in >70 years)
- Difficult to diagnose (but common)

Estimated community burden of the diabetic foot by CCG

- 282,000 population
- 11,300 diabetes
- 7,910 (70%) low risk
- 2,825 (25%) moderate-high risk
- 565 (5%) active ulceration
- Annual cost £2,791,784

The screenshot shows the NICE website interface. The main navigation bar includes links for Home, Find guidance, Putting guidance into practice, Get involved, News and press, and About NICE. The search bar is at the top right. The main content area is titled "Determining local service levels for a foot care service for people with diabetes". Below this, there is a section for "Benchmarks for a standard population".

Benchmarks for a standard population

For a **standard primary care trust population of 250,000**, the **average number of people** with diagnosed diabetes would be 9250 (3.7% of the population). All of them will require some form of foot care management including education.

Of these, approximately **324** (3.5% of 9250) may be expected to require emergency foot care treatment, and **3376** (36.5% of 9250) may require foot care and reviews at frequencies based on their elevated (increased or high) risk level.

For an **average practice** with a list size of 10,000, the average number of people with diagnosed diabetes would be 370 (3.7% of the population), of which **13** (3.5% of 370) may require emergency foot care, and **135** (36.5% of 370) may require foot care and reviews at frequencies based on their elevated (increased or high) risk level.

The table below provides estimates of the numbers of people with diagnosed diabetes at elevated risk (that is, 'increased' and 'high' risk), and the likely number of appointments that may be required according to the recommended frequencies of review in the **NICE clinical guideline CG10 on type 2 diabetes - foot care**. The full guideline on Type 1 diabetes in adults recommends following the type 2 diabetes guideline for foot care in the management of foot ulceration and associated risk factors.

Risk level	% of population	No. of patients	Frequency of review (months)	Appointments required annually	Appointments required monthly
PCT (population)					

On the right side of the page, there is a list of key points or steps:

- ▶ Foot care service for people with diabetes
- ▶ Commissioning a foot care service for people with diabetes
- ▶ Specifying a foot care service for people with diabetes
- ▶ Determining local service levels for a foot care service for people with diabetes
- ▶ Assumptions used in estimating a population benchmark
- ▶ The commissioning and benchmarking tool
- ▶ Ensuring corporate and quality assurance

Classification - ‘Critical limb ischaemia’

Definition and problems in the foot in diabetes

TASC II

“should be used for all patients with chronic ischaemic rest pain, ulcers or gangrene attributable to objectively proven arterial occlusive disease”

In any patient with diabetes and ulceration of the foot
PAD is likely to be only one aetiological factor

“What do various PAD tests do?”

- Non-invasive tests
- ABPI / toe pressure / tcpO2
- Diagnosis of PAD (first line)
- Physiological not anatomic (perfusion)
- Information on prognosis (healing / amputation)

Imaging

- Duplex / CT angiography / MRA
- Confirm diagnosis of PAD (not first line)
- Road map of disease distribution (anatomic)
- Reveal nothing about severity of perfusion deficit
- No information on prognosis / healing
- When revascularisation planned focus / guide intervention

Digital subtraction angiography

- Usually reserved for intervention
- Gold standard to detect open distal vessels
- Ever improving technology
- Reduced profile

Diagnosis of PAD in patients with DFU

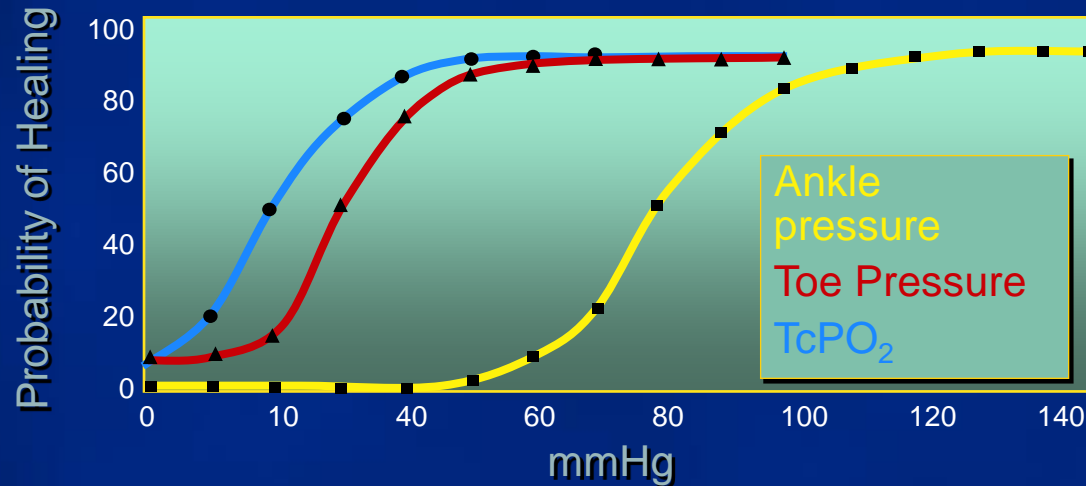
Overall test of performance

Index test	PLR	NLR
ABI <0.9	2-25 (8)	0.1-0.7 (0.3)
TBI <0.75	3	<0.1
Pulse oximetry 2% drop	30	0.2
Mono OR biphasic waveform	3-13	0.1

Brownrigg J et al. Diabetes Metab Res Rev. 2016;32:119-27

Prognosis (healing)

Hemodynamics and Probability of Healing of Diabetic Foot Ulcer



Healing unlikely if toe pressure < 55 mmHg

Prognosis (healing)

Annualised healing rates 18-61%

Index test	PLR
Ankle pressure >50mmHg	1.1-1.5
Ankle pressure >70mmHg	2.5-3.2
ABI 0.9-1.3	2.6
TcPO ₂ ≥25 mmHg	10
Toe pressure ≥ 30mmHg	1.1-5.0
Toe pressure ≥ 45mmHg	2.9-4.3
SPP ≥ 40mmHg	4.9-6.4

Prognosis (major amputation)

Annualised major amputation rates 3-19%

Index test	PLR
Ankle pressure <50mmHg	1.3
Ankle pressure <70mmHg	4.3
Ankle pressure <50mmHg or ABI <0.5	8.2
Toe pressure < 30mmHg	2.6
Toe pressure < 45mmHg	2.1
Fluorescein toe slope (<18 units)	4.0
Monophasic / absent doppler	2.2

When to revascularise?

*Trust the ABPI when low
not when high*

- ABPI >0.6 (toe pressure $>55\text{mm Hg}$, TcPO₂ $>50\text{mm Hg}$) trial of 6 weeks of best wound care and assess response
- ABPI <0.6 (toe pressure and/or TcPO₂ $<30\text{mm Hg}$) or wound healing response poor consider early revascularisation



When to revascularise?

*Trust the ABPI when low
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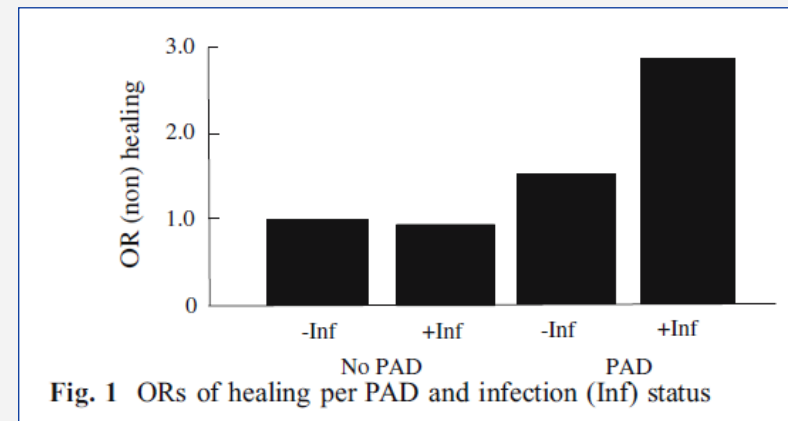


Diabetes Metab Res Rev. 2012;28 Suppl 1:236-7

When to revascularise?

*Trust the ABPI when low
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- ABPI >0.6 (toe pressure >55 mm Hg tcpO₂ >50 mm Hg) trial of 6 weeks of best wound care and assess response
- ABPI <0.6 (toe pressure and/or tcpO₂ <30 mm Hg) or wound healing response poor consider early revascularisation



Diabetologia (2008) 51:747–755

Decision to revascularise

- Complex assessment and decision
- Multi-factorial
 - **Ulcer** – infection, size, depth
 - **Limb** – perfusion deficit, distribution of PAD, conduit
 - **Patient** – co-morbidity, long-term survival, preference
- Lack of evidence
- Single professional decision making is sub-optimal

What proportion of patients with PAD and ulceration revascularised?

- 2003
- 14 experienced European centres
- 1,088 diabetes patients (PAD n=505)
- ABI <0.5 (n=94)
- Revascularisation 43%
- Endovascular 22% and/or bypass 27%



Natural history of severe PAD in DFU

Outcome	No angiography <i>n</i> = 319 (53%)	Angiography without intervention <i>n</i> = 283 (47%)	Total <i>n</i> 602 (100%)
Ongoing ulcer	2 (—)	2 (—)	4 (—)
Primary healing	119 (37)	108 (38)	227 (38)
Healed after minor amputation	34 (11)	38 (13)	72 (12)
Healed after major amputation	40 (13)	61 (22)	101 (17)
Deceased unhealed with/without amputation	123 (38)	74 (26)	197 (33)
Drop out	1 (—)	0 (—)	1 (—)

Elgzyri T, Eur J Vasc Endovasc Surg. 2013;46:110-7

Which patients with diabetes and PAD require revascularisation?

	All patients OR (95% CI)
Pain at rest	0.59 (0.38–0.91)
Ankle pressure >50 mmHg	2.44 (1.27–4.66)
Serum creatinine >130 µmol/L	0.55 (0.34–0.88)
Ischemic heart disease	0.52 (0.34–0.81)
Cerebrovascular disease	0.41 (0.27–0.64)
Max. Wagner grades ≥3 reached	0.51 (0.33–0.77)

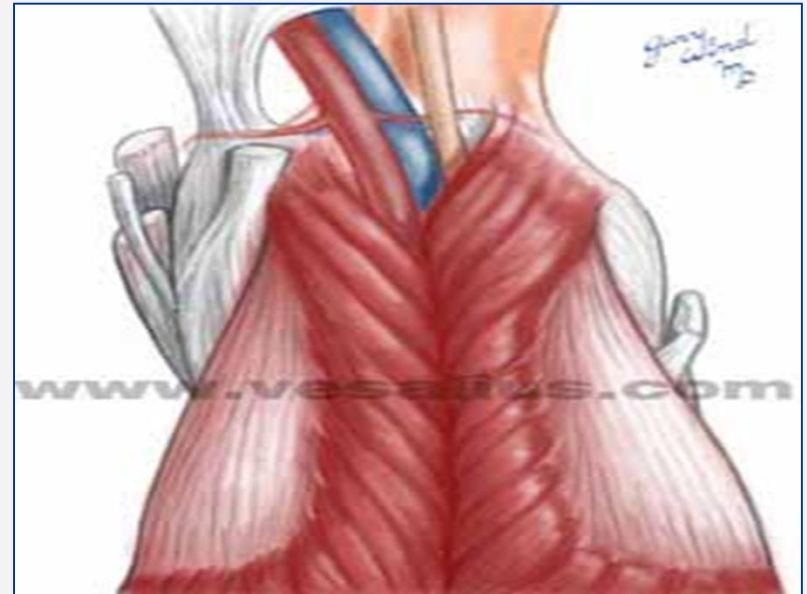
Elgzyri T, Eur J Vasc Endovasc Surg. 2013;46:110-7

Conclusions

- The majority of patients with DFU have PAD
- PAD associated with premature deaths and amputations
- Revascularisation decision not straight forward
- Not all require revascularisation (many do)
- Improved assessment of perfusion

Popliteal entrapment

- Anatomical variant 1879
- First operation 1959
- Entrapment syndrome 1965



Epidemiology

- 0.17-3.5% anatomic predisposition
- Males 9:1 Females
- Mean age 32 (20.7-41) years
- 38% bilateral
- Symptom duration 24 months

Popliteal entrapment syndrome

Sidhartha Sinha, MA, MRCS,^a Jon Houghton, MRCP, MFSEM,^b Peter J. Holt, PhD, FRCS,^a
Matt M. Thompson, MD, FRCS,^a Ian M. Loftus, MD, FRCS,^a and Robert J. Hinchliffe, MD, FRCS,^a
London and Surrey, United Kingdom

Introduction: Popliteal entrapment syndrome (PES) is a rare but important cause of intermittent claudication in young people. Controversy exists about optimal strategies for diagnosis and management, particularly for variants such as functional popliteal entrapment. The aim of this review was to systematically catalog the published English-language literature on PES and to determine if evidence-based guidelines for management could be formulated.

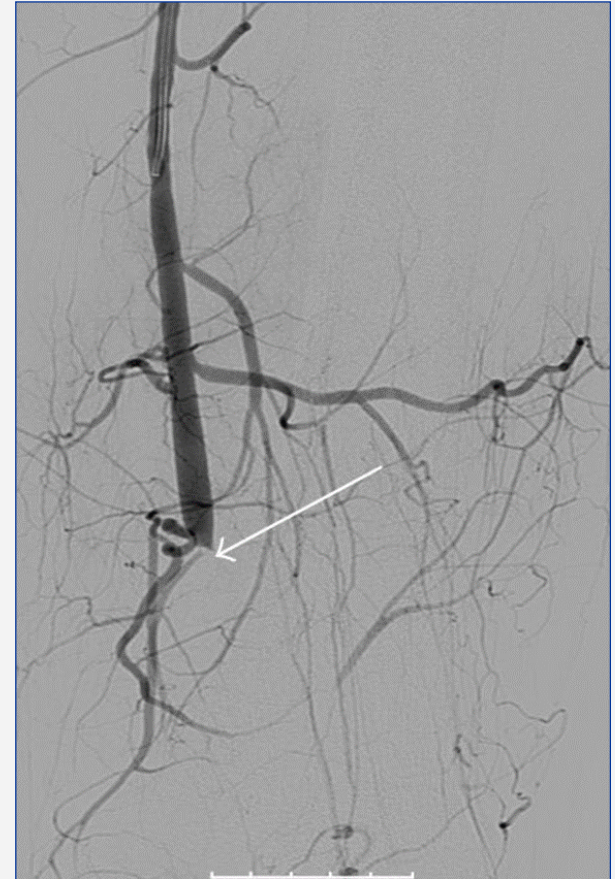
Methods: An electronic search using the MEDLINE, EMBASE, Cochrane Library, AMED, and CINAHL databases was performed to identify articles about PES published from 1947 to December 2010. The systematic review conformed to Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement standards. Prospective studies and retrospective case series with more than five patients with arterial, venous, nerve, and combined neurovascular entrapment were analyzed on a study-by-study narrative basis.

Results: The search identified 291 articles, and 44 were included. Of these, 30 studies were on popliteal artery entrapment syndrome (PAES). No relationship was found between duration of symptoms and the presence of irreversible arterial injury. Each study used a median of three diagnostic tests (range, 1-6). Arteriography was used in 28 of 30 studies to diagnose PAES, with an estimated mean sensitivity of 97% (range, 85%-100%). Twenty-three studies described arterial reconstructive procedures, with a median failure rate of 27.5% (range, 0%-83%). The proportion of patients asymptomatic after surgery was reported in only 12 of 30 studies, with a median value of 77% (range, 70%-100%).

Conclusions: A large volume of predominantly retrospective clinical data exists on PES. A subset of studies describe a significant failure rate after surgery, but study quality is insufficient to derive robust conclusions allowing recommendation of any one particular diagnostic modality or operative procedure over another. Improvements in management of this condition are unlikely to result from publication of further retrospective case series, and clinicians should concentrate on prospectively collected data with predefined inclusion criteria, outcome measures, follow-up protocols, and transparent standardized reporting criteria. (J Vasc Surg 2012;55:252-62.)

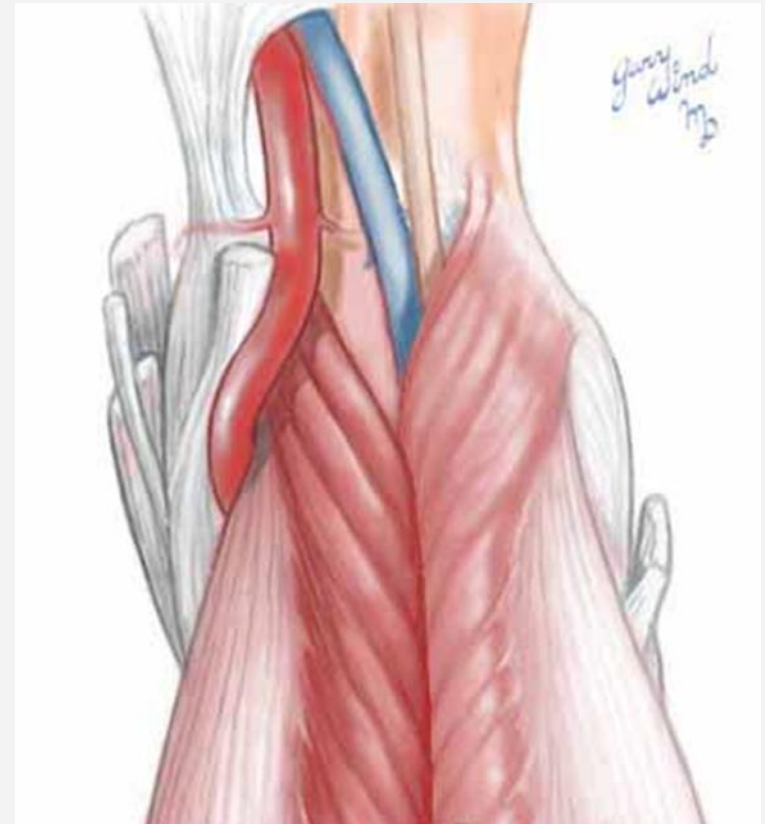
Presentation

- Symptom duration 24 months
- Intermittent claudication (calf)
- 11% acute limb ischaemia
- 17.5% (6-31%) asymptomatic
- Foot symptoms (neurological)



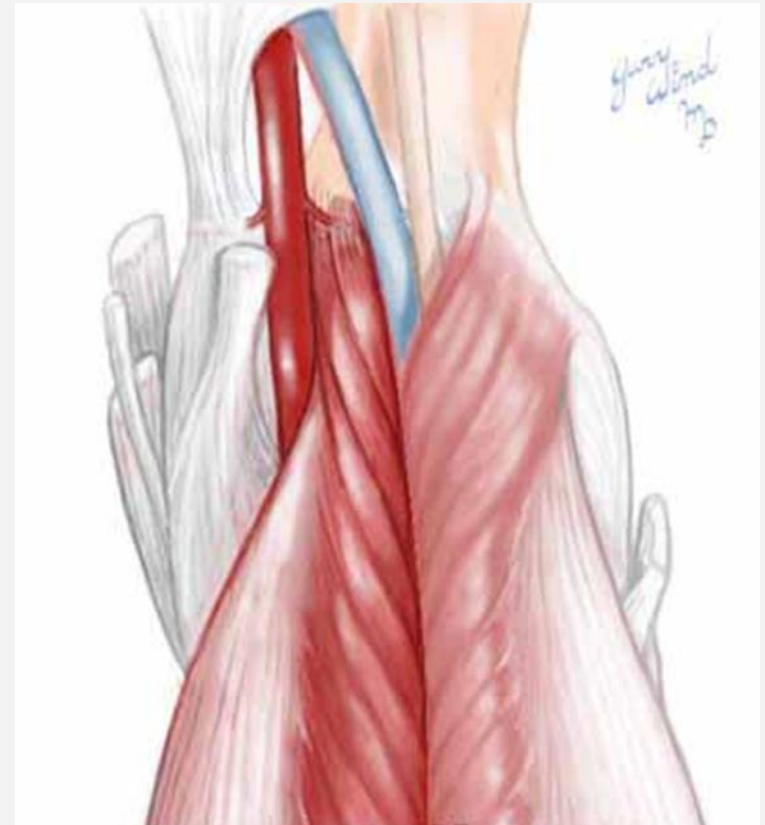
Classification – Type I

- Popliteal artery passes medial to and under a normal medial gastrocnemius head
- The vein remains in its normal position



Classification – Type II

- Medial head of the gastrocnemius inserts more lateral than normal
- Artery descends in a straighter path around the medial margin of the muscle



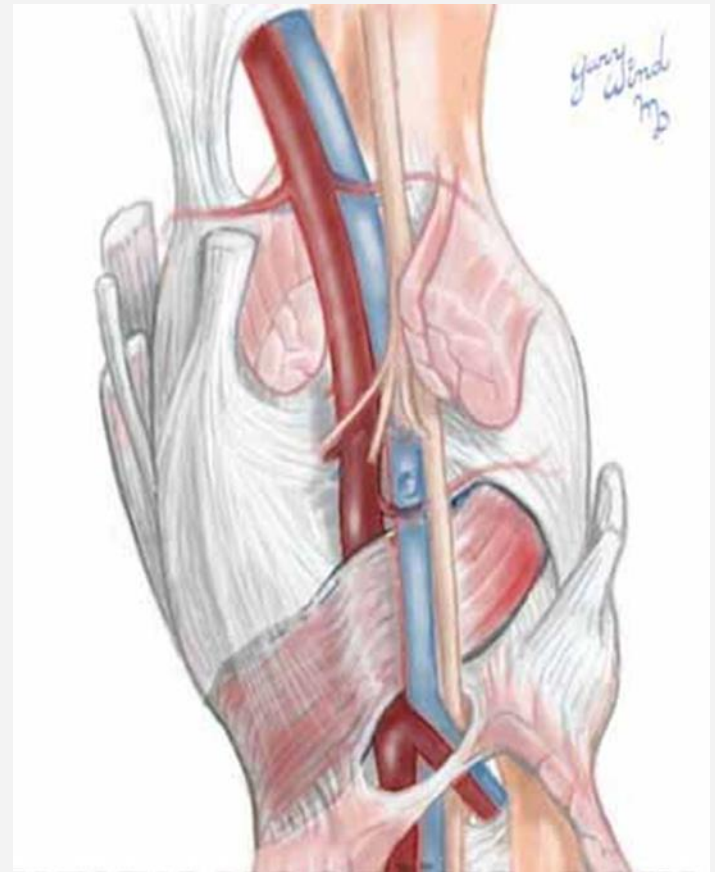
Classification – Type III

- Artery is compressed by a slip of the medial head arising more laterally than normal
- Artery passes through the body of the medial head in a relatively straight path



Classification – Type IV

- Popliteal artery passes deep to the popliteus muscle or a band, with or without associated gastrocnemius abnormality
- Reflects a persistence of a more primitive embryological vascular pattern of the leg



Classification – Type V

- Any of the preceding types with the addition of popliteal vein entrapment
- Rare

Type VI – ‘functional’

- Extrinsic compression of the popliteal artery without identification of anatomical alterations
- Hypertrophy of the gastrocnemius muscle
- 23% (6.3-88%)
- ?Soleal sling involvement
- ? a risk factor for future vascular complications



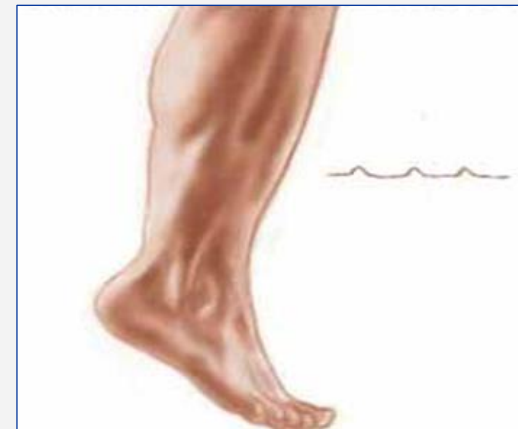
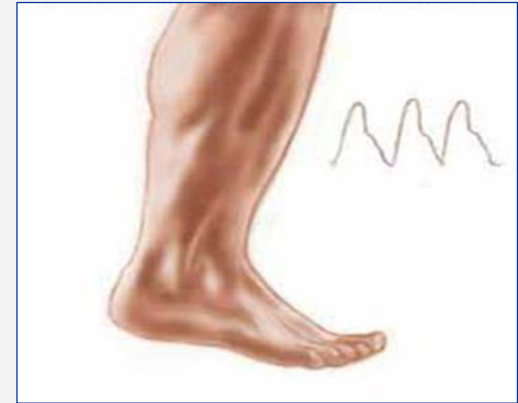
Histological changes with continued entrapment

- Stage I Adventitial thickening and fibrosis
- Stage II Medial disease
- Stage III Intima

- ANEURYSM / OCCLUSION

Clinical examination

- Popliteal bruit
- ABPI drop post exercise?
- Active plantar flexion diminish foot pulses



Differential diagnosis

- Arterial
- Musculoskeletal
- Neurological

Musculoskeletal

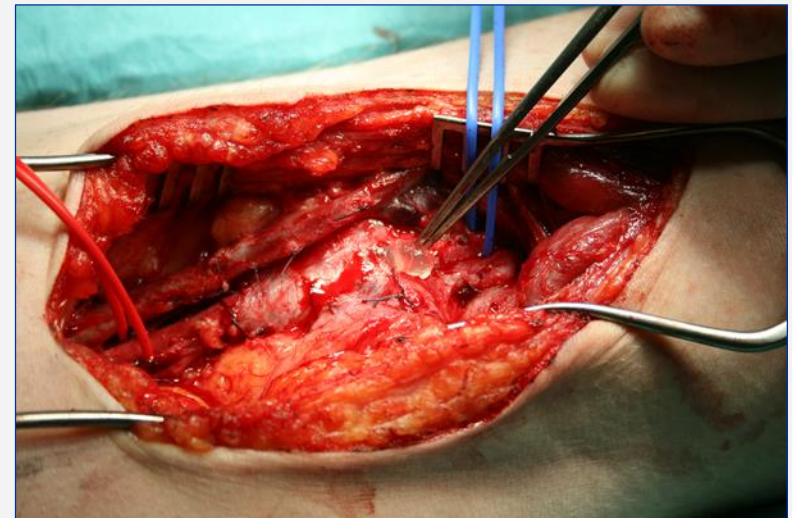
- Gastrocnemius or soleus strain
- Compartment syndrome
(resting pressure >20mm Hg, normal <15)
- Stress fractures
- Periostitis
- Tibialis posterior tendonitis

Neurological

- Back pain
- Spinal stenosis
- Neuropathy

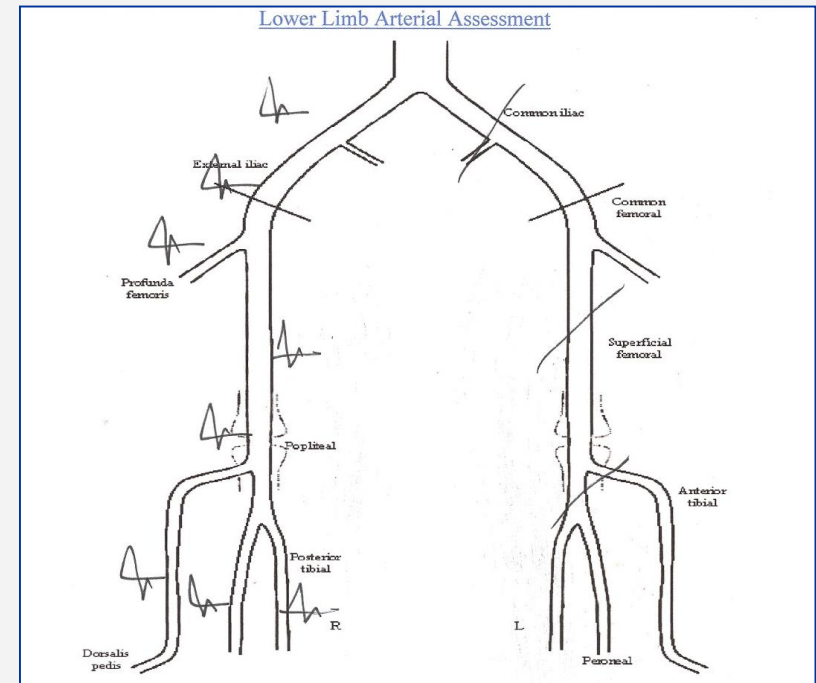
Other causes of claudication in young patients

- Cystic adventitial disease
- Iliac endofibrosis
- Persistent sciatic arteries
- Dissection
- Atherosclerosis



Investigations

- History
- Clinical examination
- ABPI resting / exercise
- Arterial duplex
- MR angiogram
- Digital subtraction angiography



Duplex ultrasound

- Occlusion on provocation
- Normal individuals – 56% (7-80%)
- No difference
'athletic -v- 'non-athletic'



FR 20Hz

R1

2D

45%

C 50

P Low

Gen

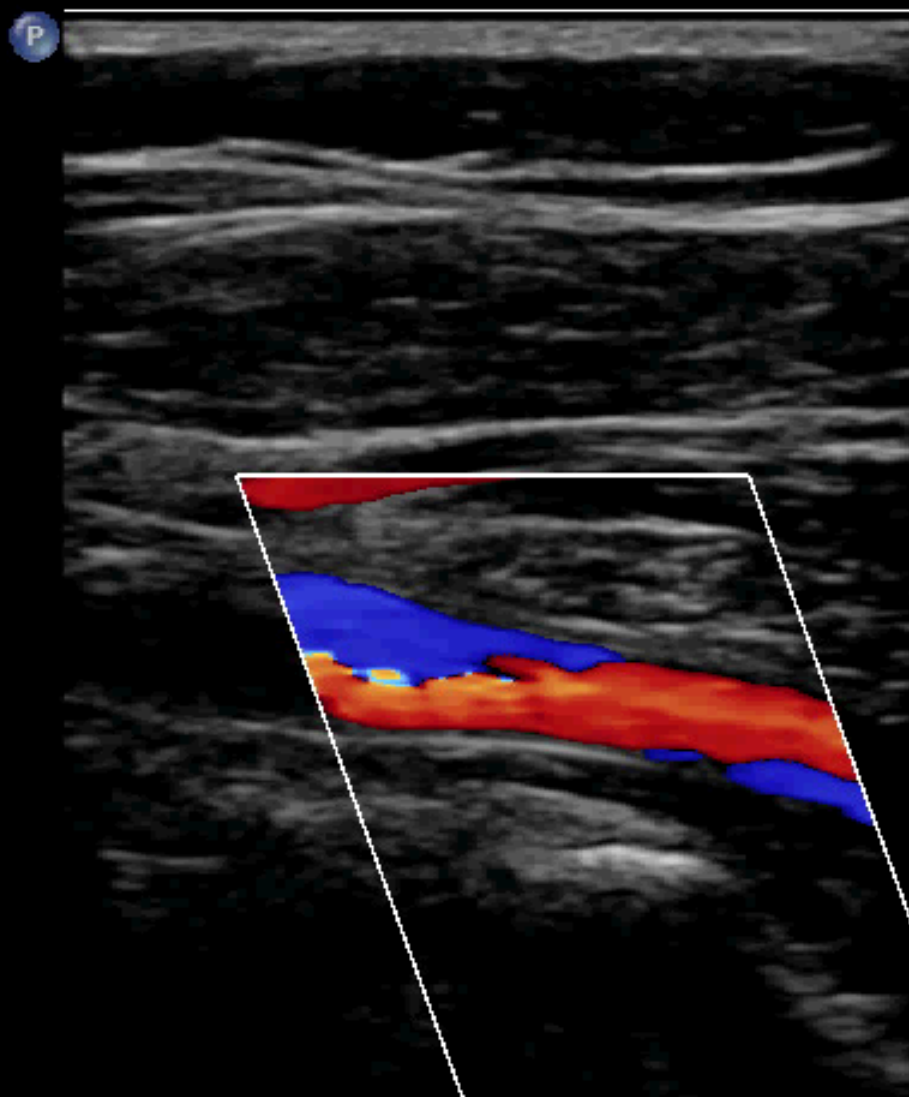
CF

64%

2000Hz

WF 90Hz

Med



M2 M3

+19.3

-19.3

cm/s

JPEG

5.0- *** bpm

42241420100813

L9-3/Vasc Ven

FR 20Hz 60°

R1

2D

43%

C 50

P Low

Gen

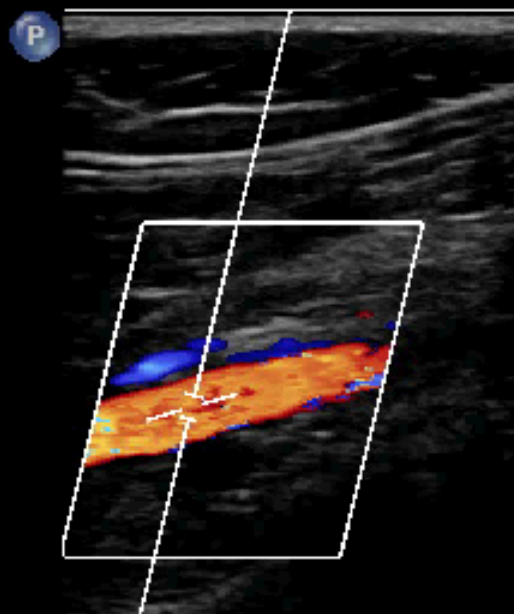
CF

64%

2000Hz

WF 90Hz

Med



PW

72%

WF 60Hz

SV2.0mm

M3

3.5MHz

3.4cm

M2 M3

+19.3



-19.3

cm/s

-160

-120

-80

-40

-cm/s

-40

*** bpm

JPEG

6.6sec

FR 22Hz

R1

2D

45%

C 50

P Low

Gen

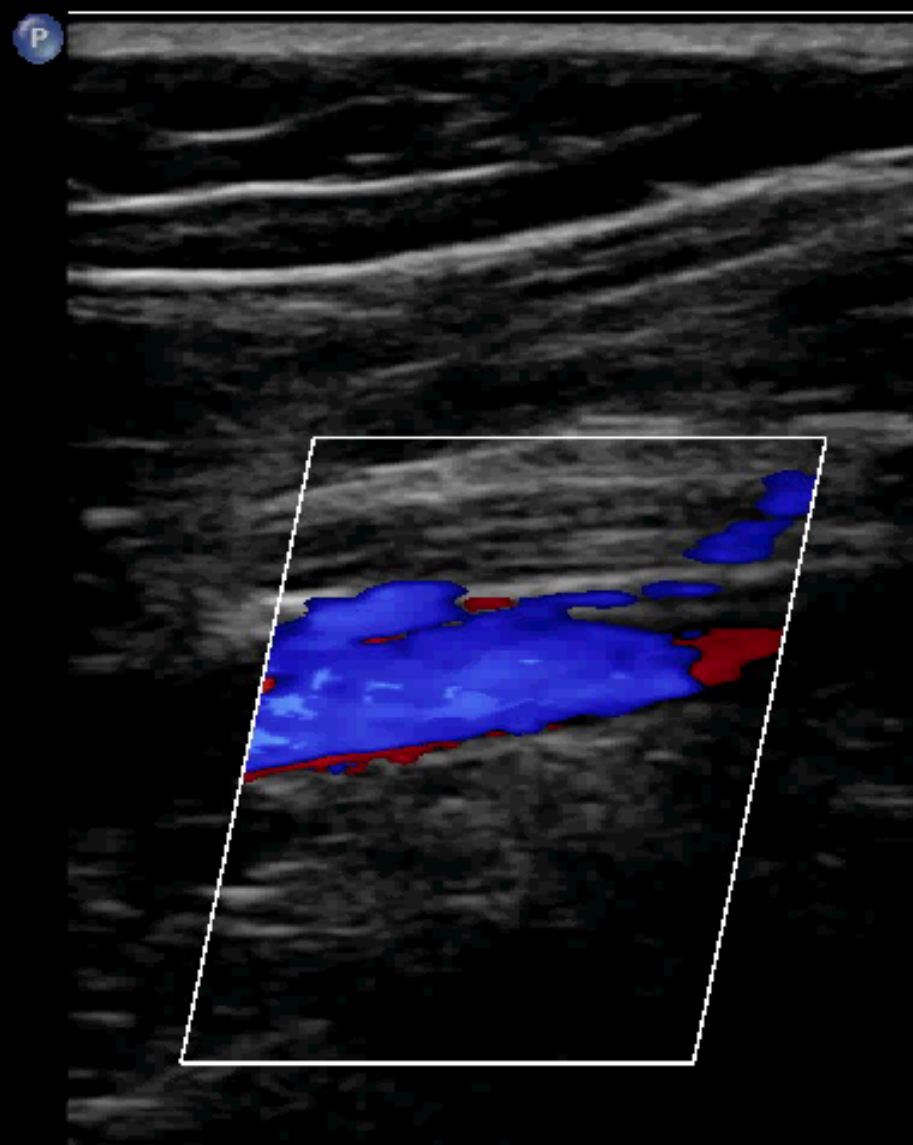
CF

64%

1500Hz

WF 52Hz

Med



M2 M3

+14.4



-14.4

cm/s

JPEG

5.0- *** bpm

42241420100813

L9-3/Vasc Ven

FR 18Hz 60°

R1

2D

45%

C 50

P Low

Gen

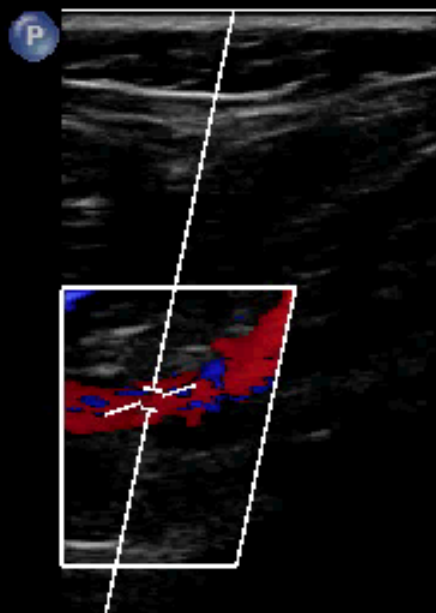
CF

64%

1500Hz

WF 52Hz

Med



PW

76%

WF 60Hz

SV2.0mm

M3

3.5MHz

4.0cm

M2 M3

+14.4



-14.4

cm/s

6.0

-180

-120

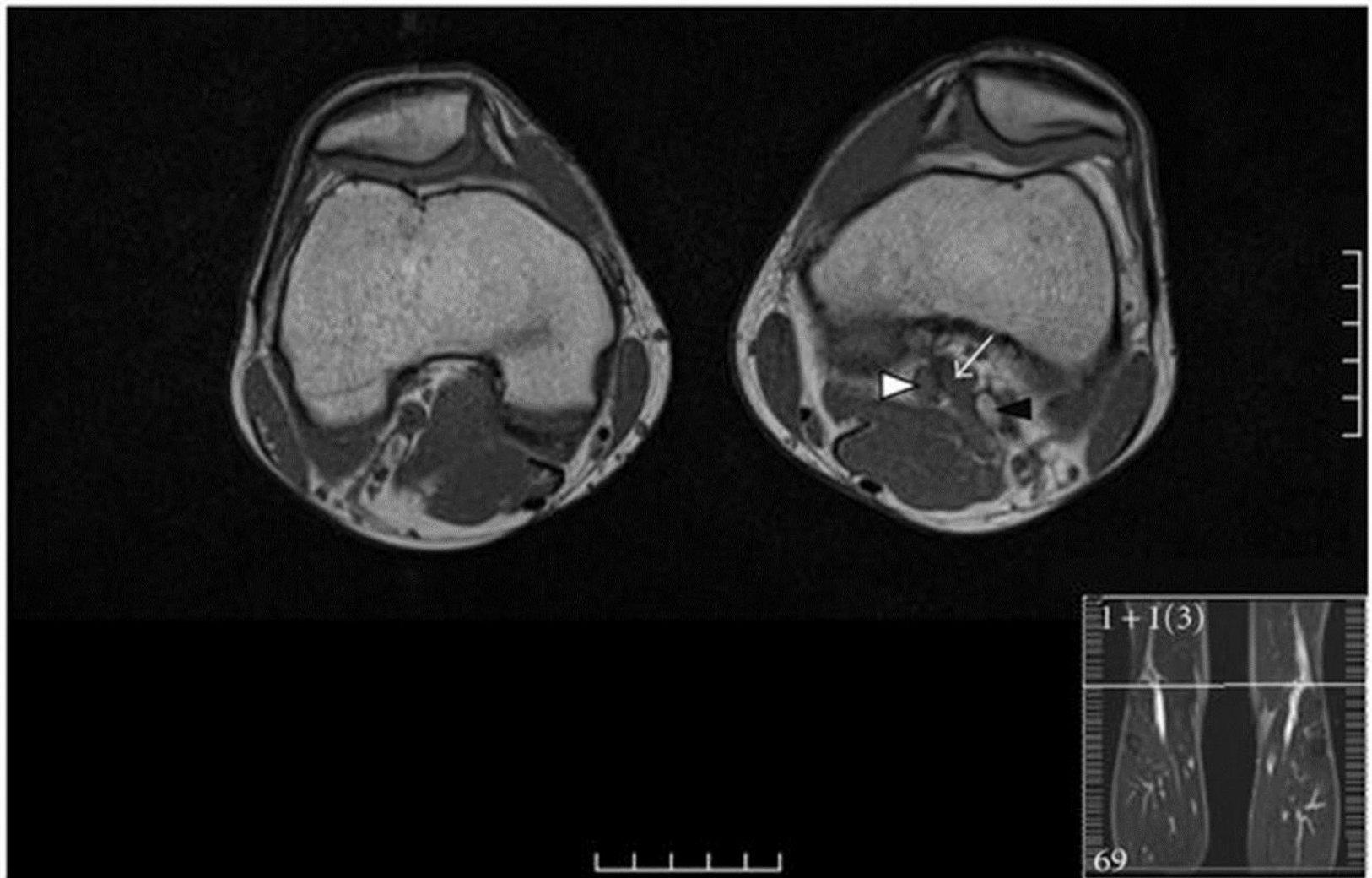
-60

-cm/s

*** bpm

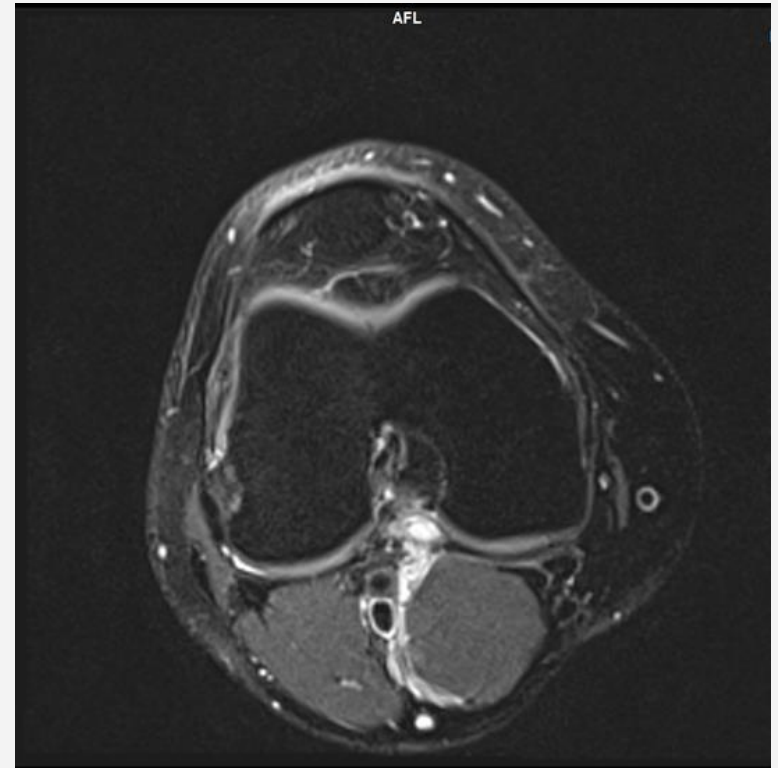
JPEG

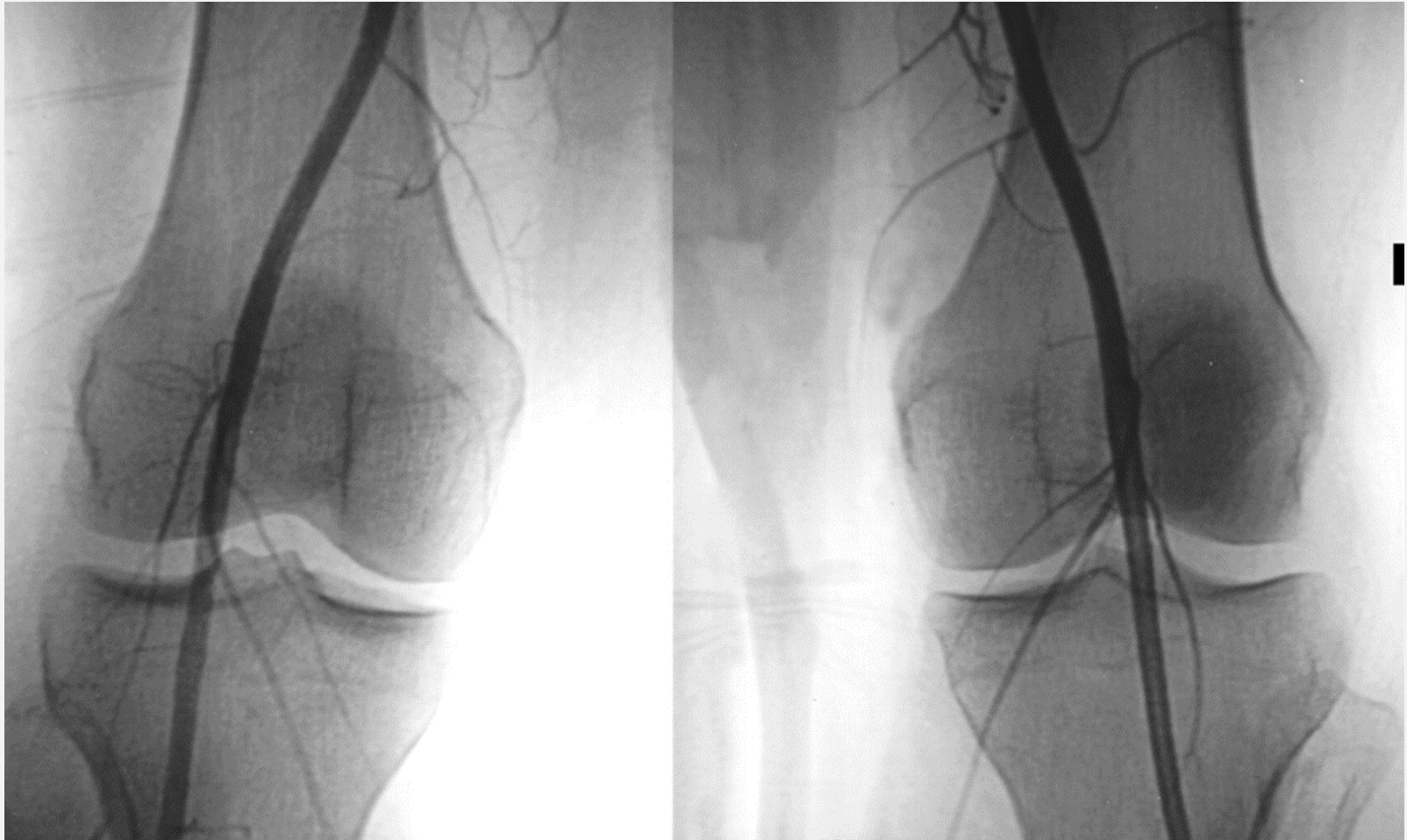
6.6sec

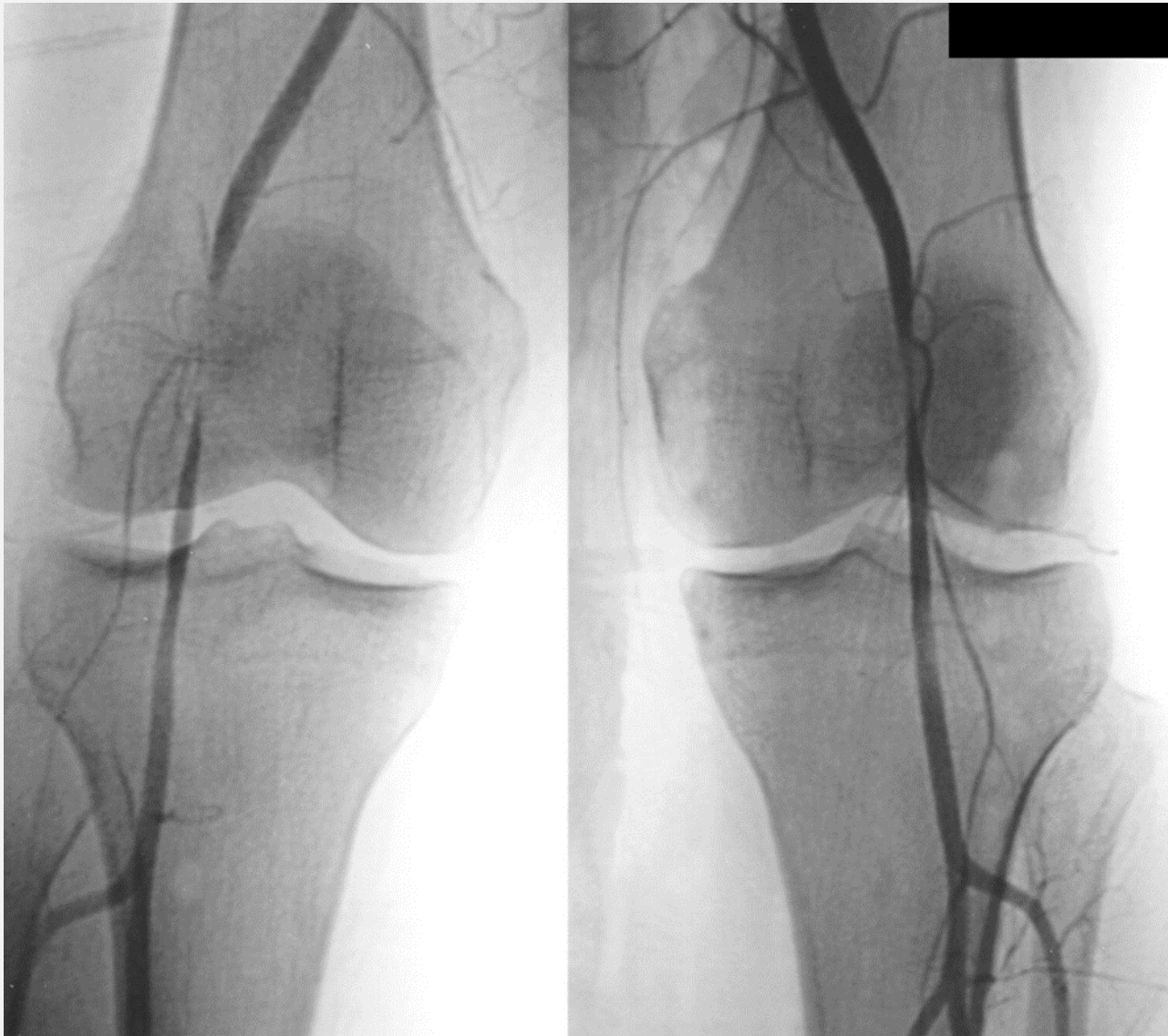




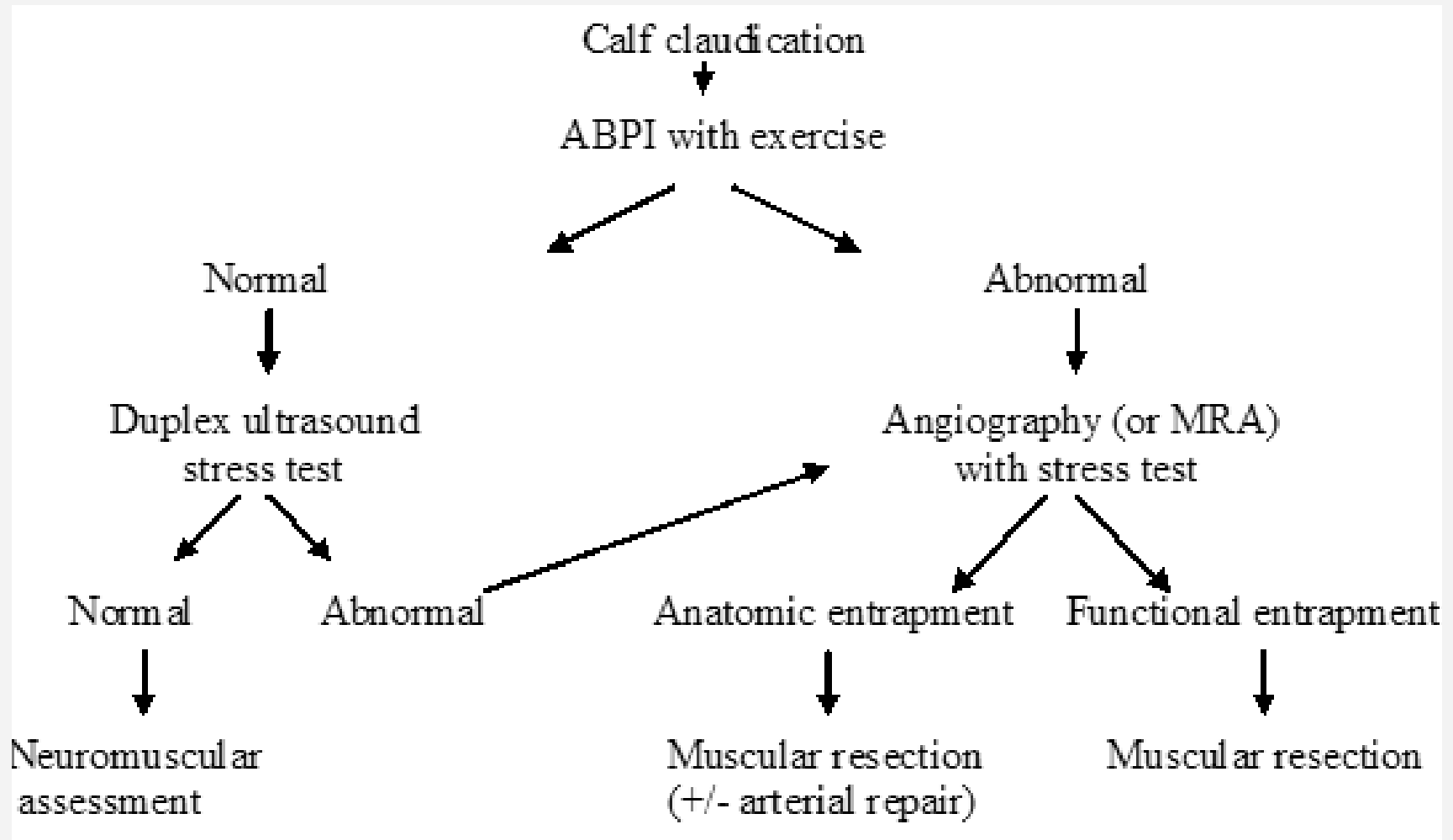
Excluding alternative causes of pain – MR angiography



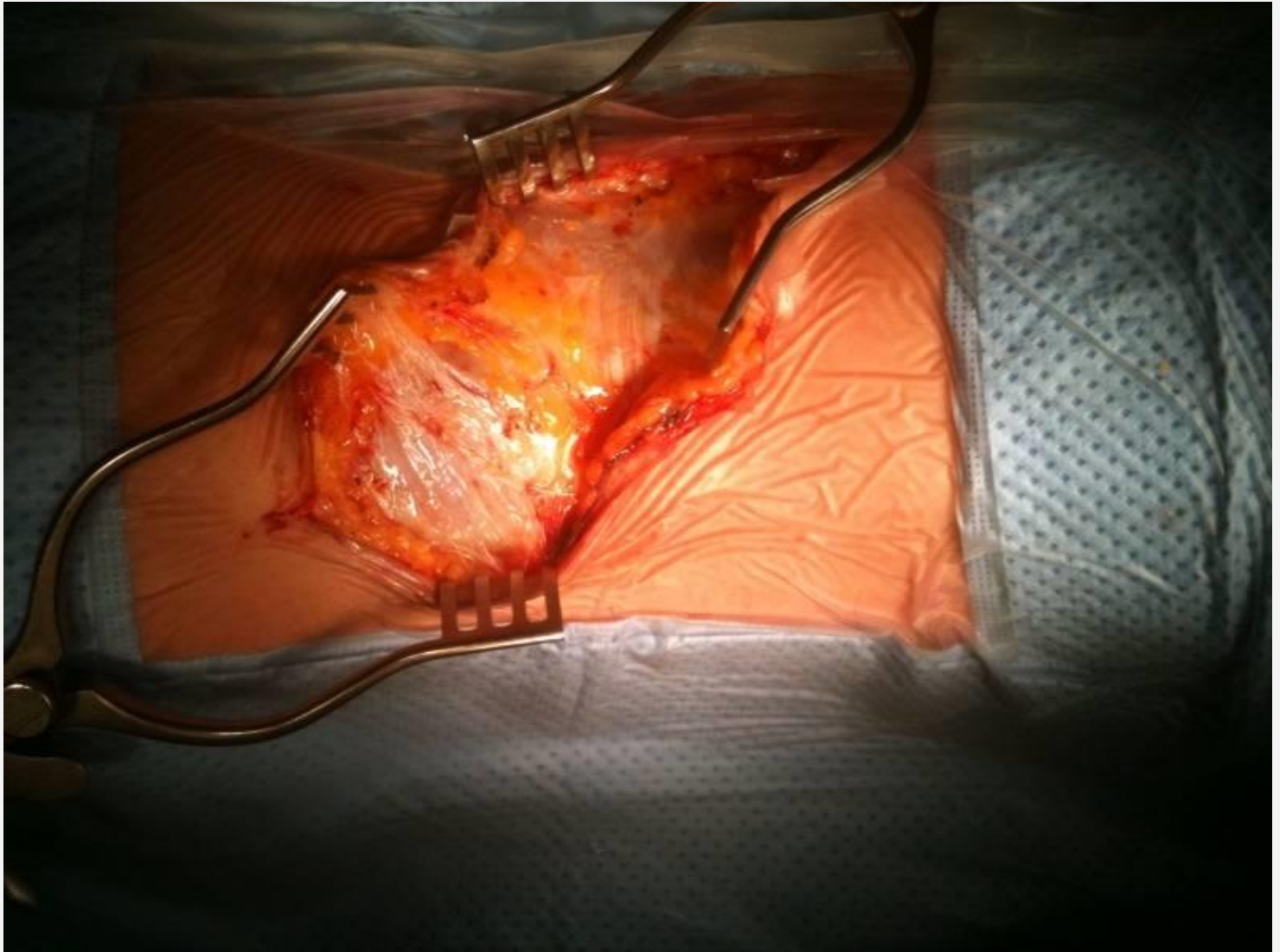


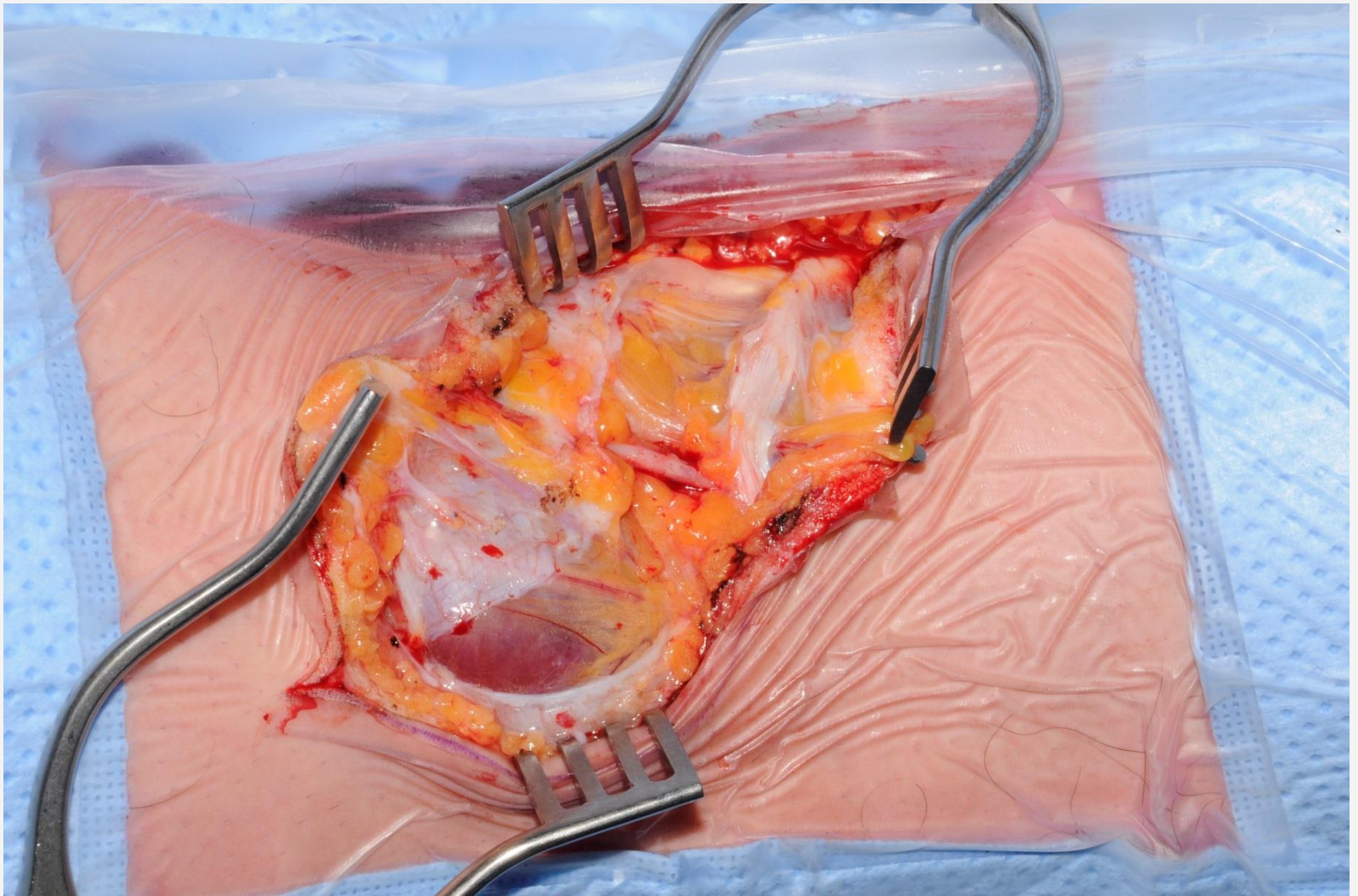


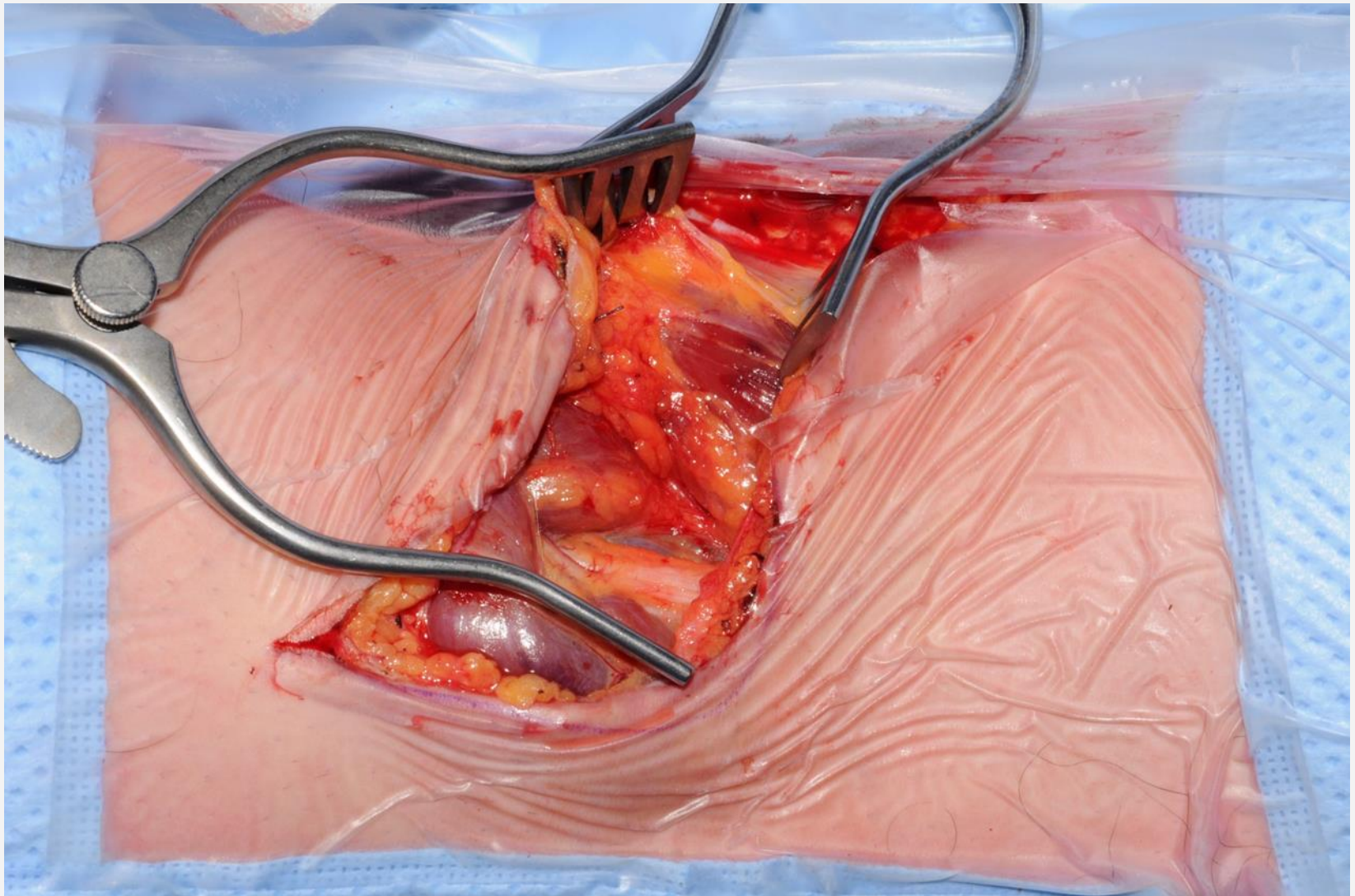
Investigation pathway

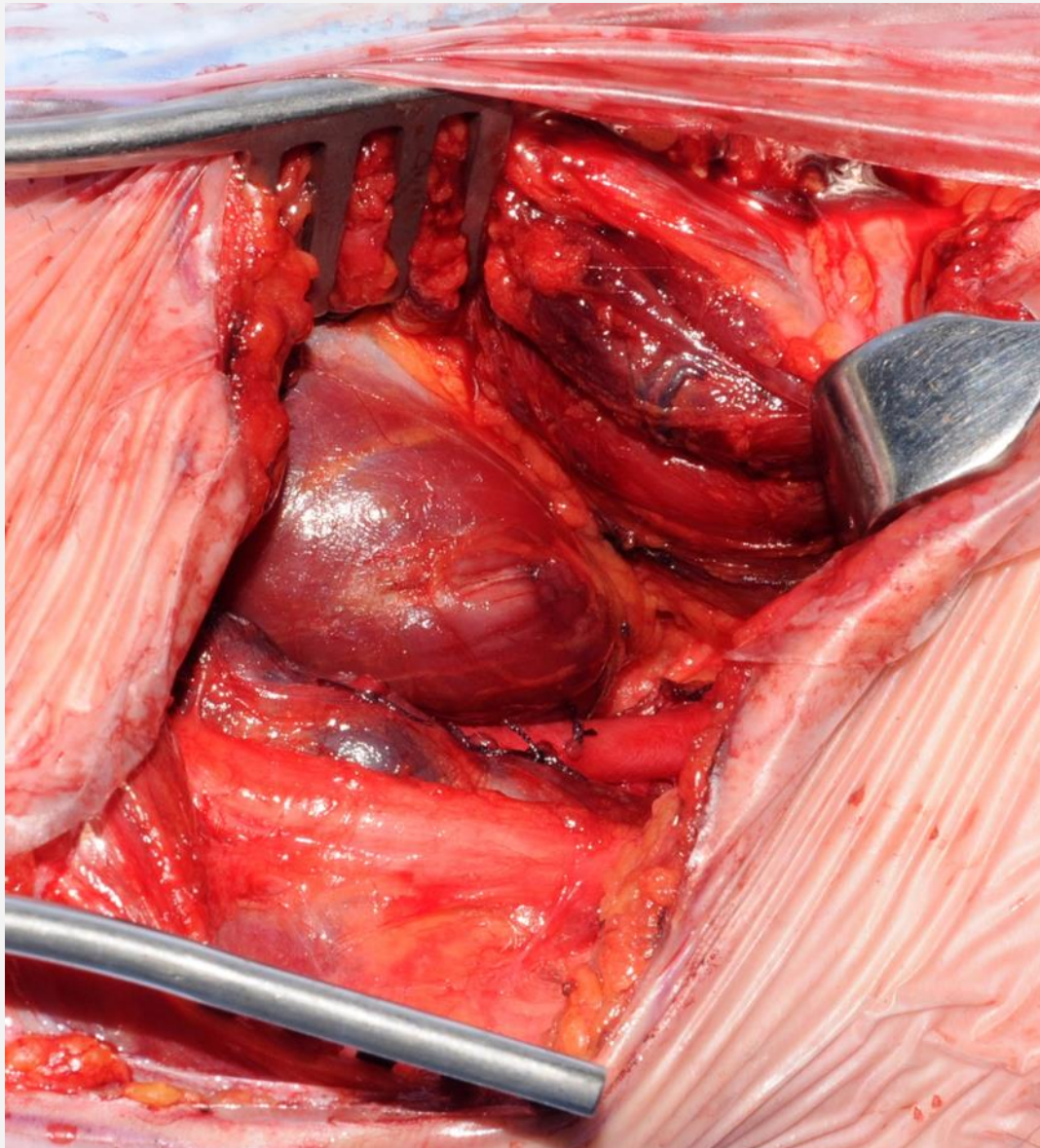


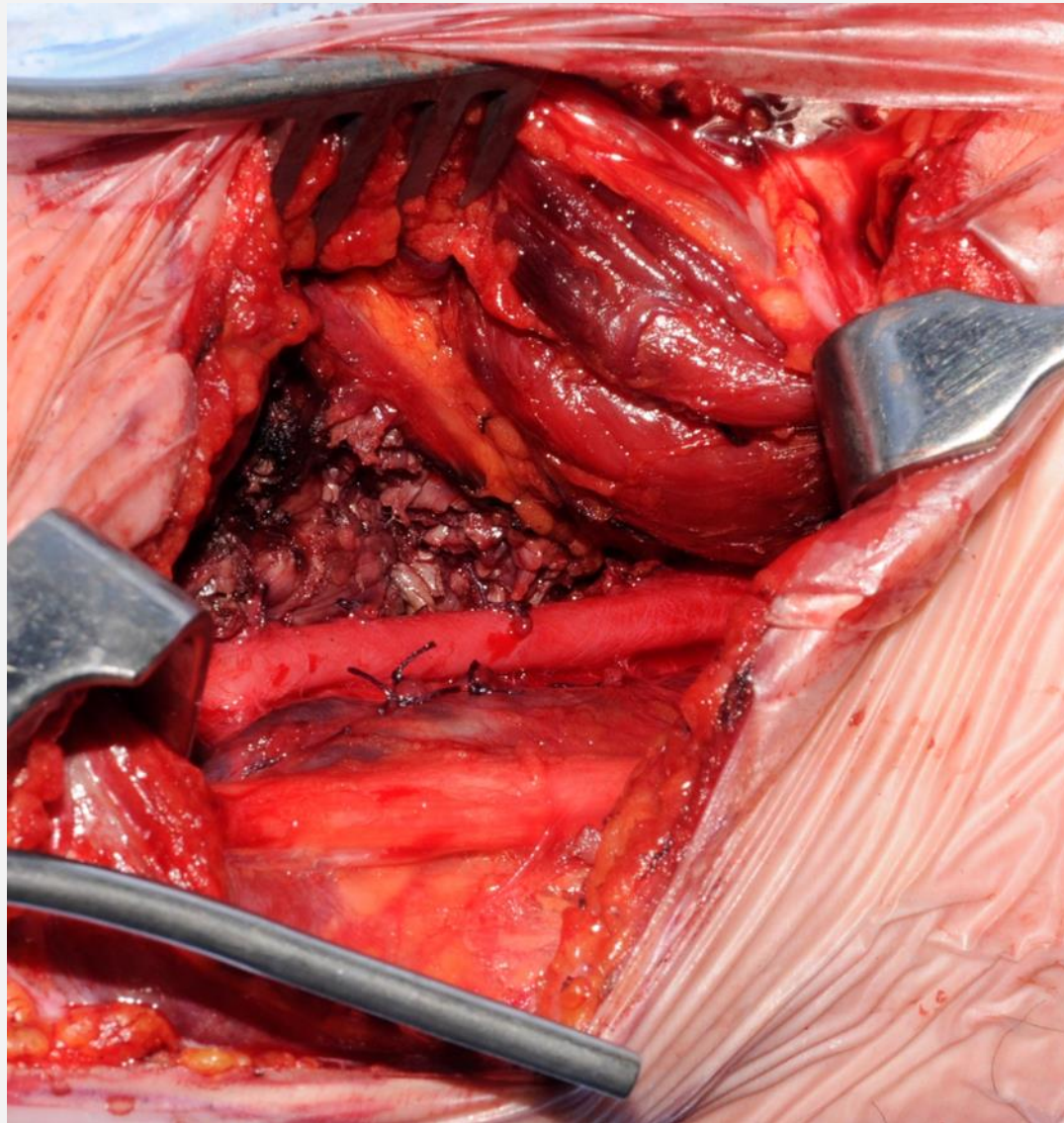












Intra-operative assessment

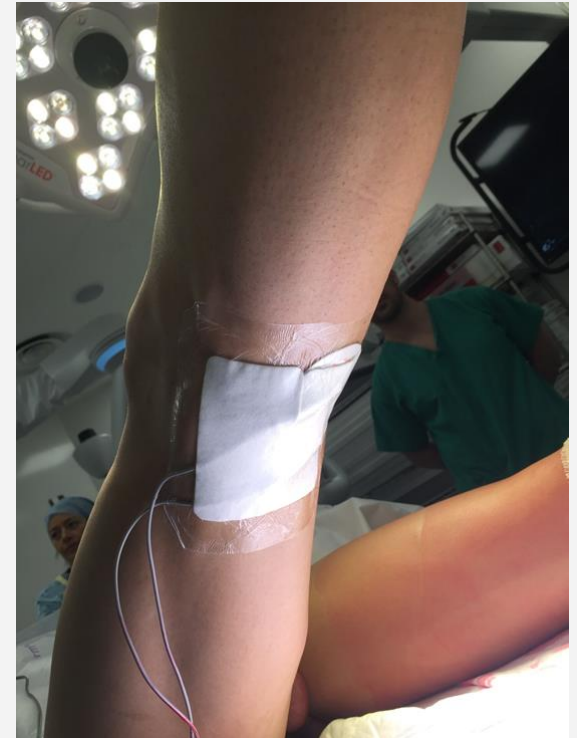


Intra-operative control

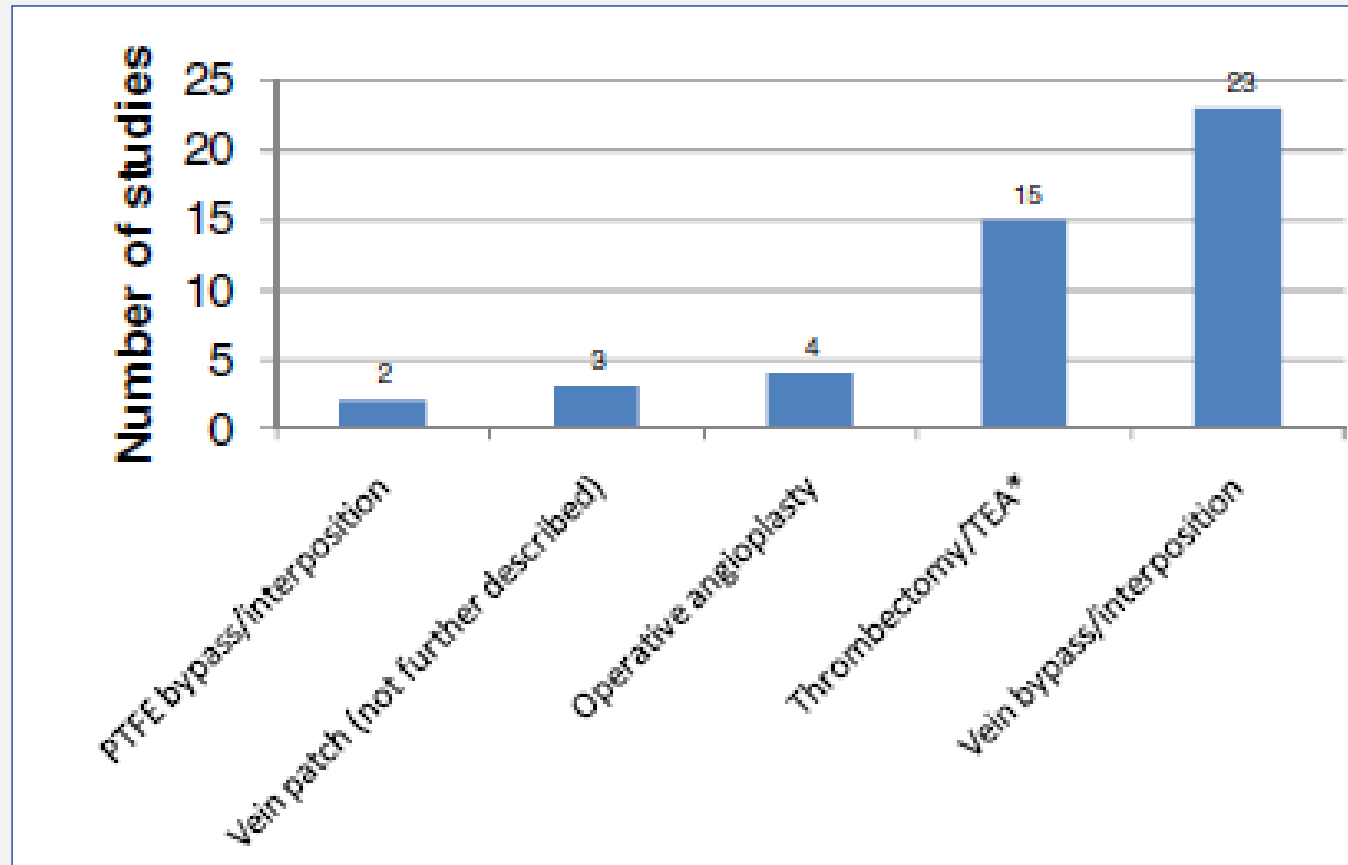


Intra-operative control

- Nerve stimulator
- Access to pedal vessels
- Duplex control
- Medial below knee popliteal approach
- Resect medial head gastrocnemius



Arterial reconstruction



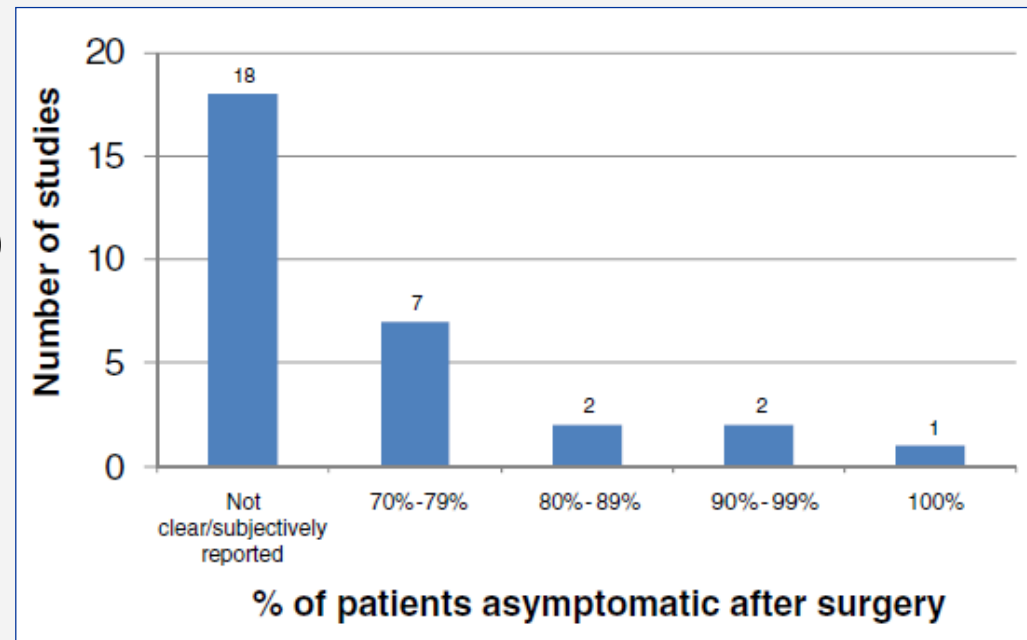
Surgical complications

- Graft related
- Nerve damage (sural/tibial/common peroneal)
- Bleeding
- DVT
- Wound infection
- Skin contracture

- Failure to relieve symptoms

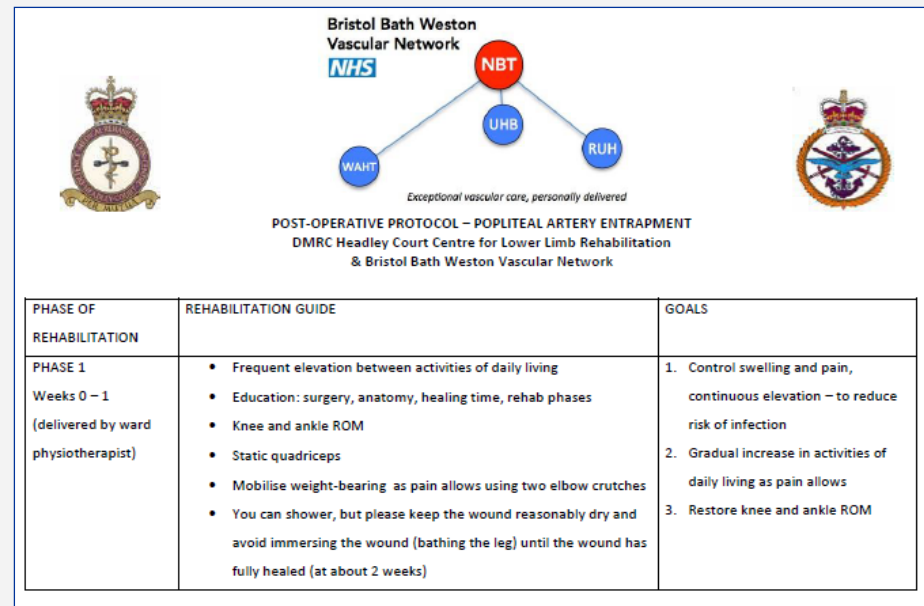
Outcomes of surgery

- Paucity of data
- Successful resolution symptoms 77% (70-100%)
- Nabil Chakfe 5 years data EJVES 2016



Post-operative recovery

- Dedicated rehabilitation schedule
- Bed rest 48 hours
- Crutches 3-4 days
- Non-impact aerobic rehab 1 week
- 4-6 weeks low impact running



Conclusions

- Dedicated referral pathway (musculoskeletal specialist)
- Diagnostic algorithm (exercise ABPI, Duplex, MRA)
- Majority functional
- Medial approach favourable (medial head gastrocnemius)
- Intra-operative Duplex control
- Dedicated rehabilitation schedule
- Long-term / functional data sparse

Diagnostic algorithm in normal population – functional entrapment syndrome

Iliac endofibrosis

- First described in 1985
- High performance athletes
- Unexplained leg symptoms



Epidemiology

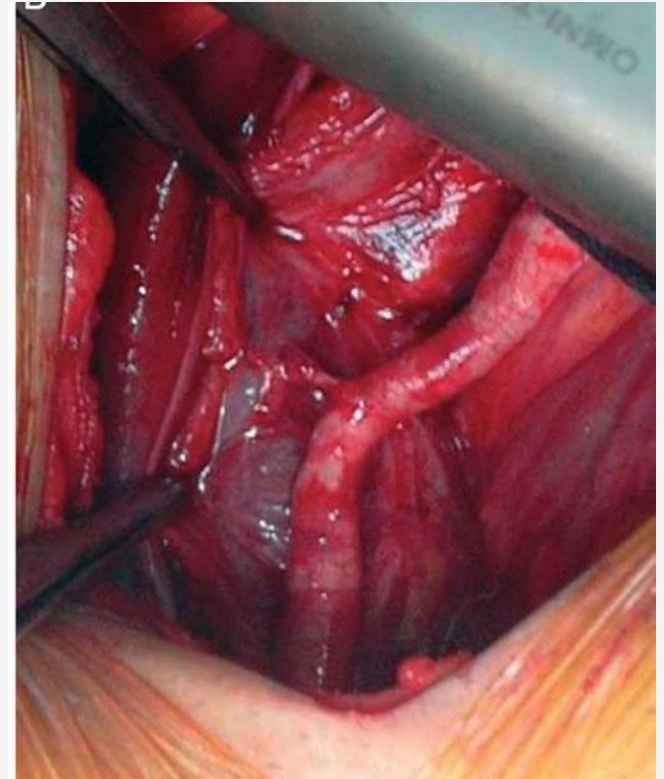
- Mainly cyclists
- Distance cycled (>15,000km per year)
- Intensity of training
- <40 years
- 78% male
- Incidence unknown
- External iliac artery (CIA / CFA / profunda)

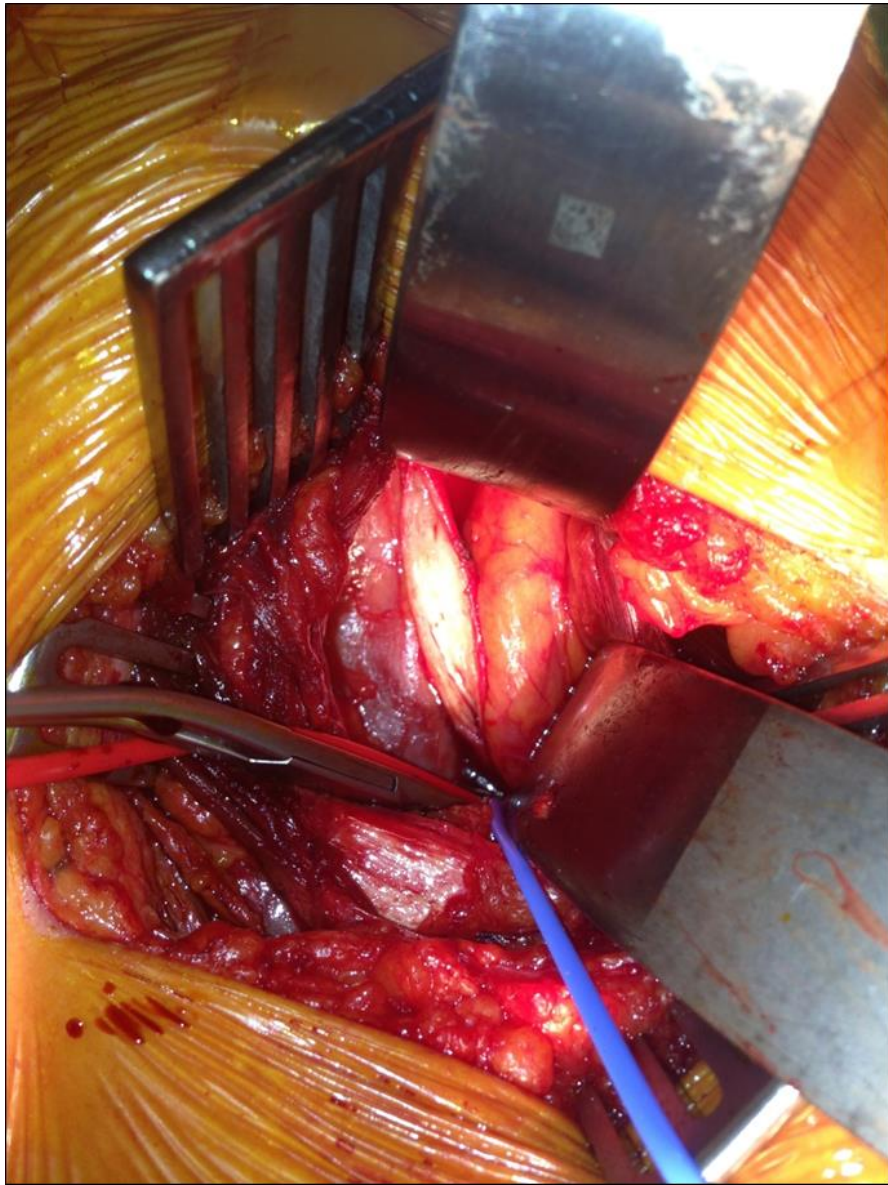
Aetiology

- Inter-play of two major factors
- Haemodynamic injury (shear stress / high blood flow)
- Mechanical stress (repetitive stretching / position)

Mechanical factors

- Repeated stretching
- Psoas hypertrophy
- Arterial fixation
- Excessive vessel length
- Kinking
- External compression
- Systemic factors (homocysteine)?

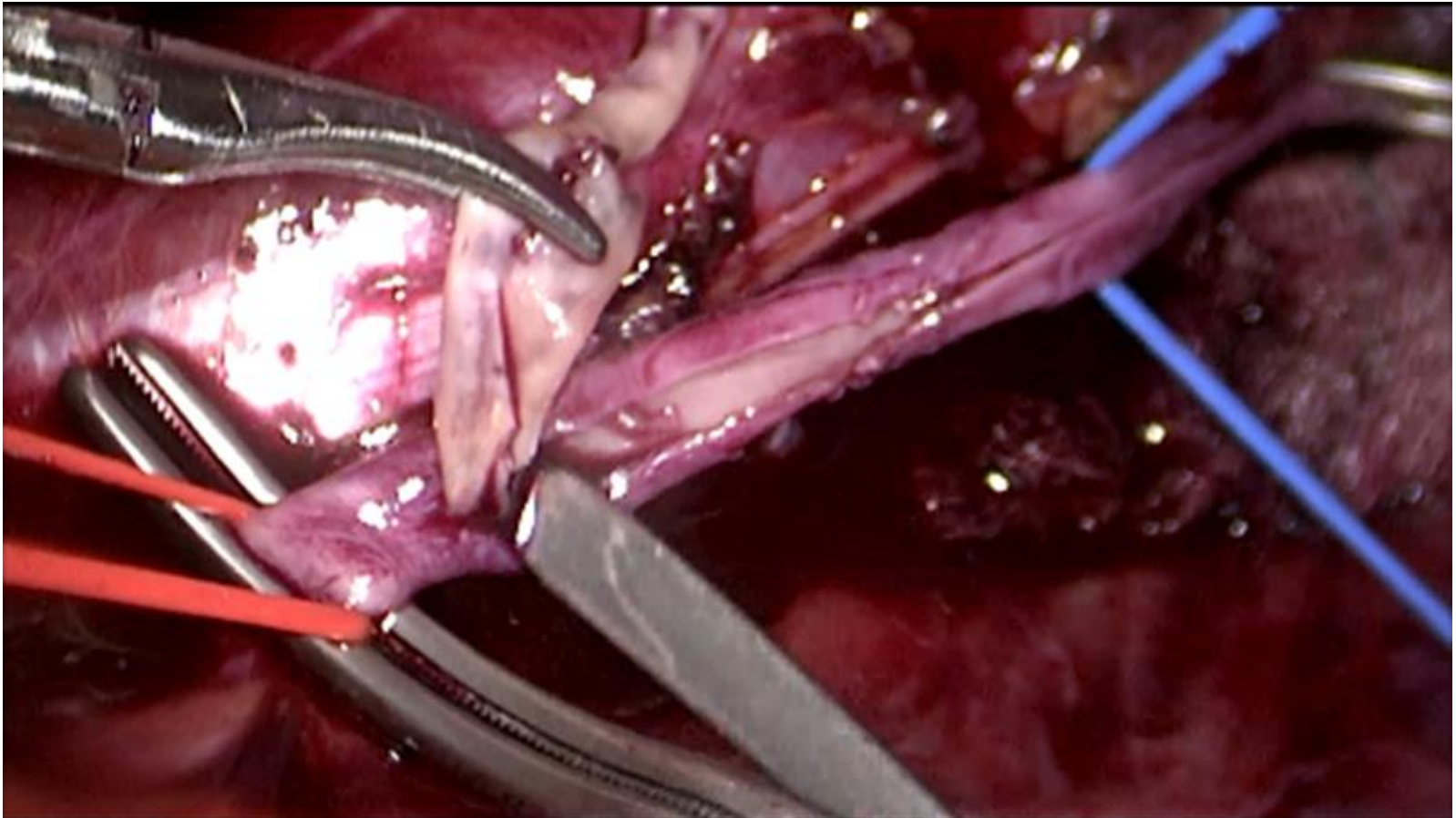




Pathology

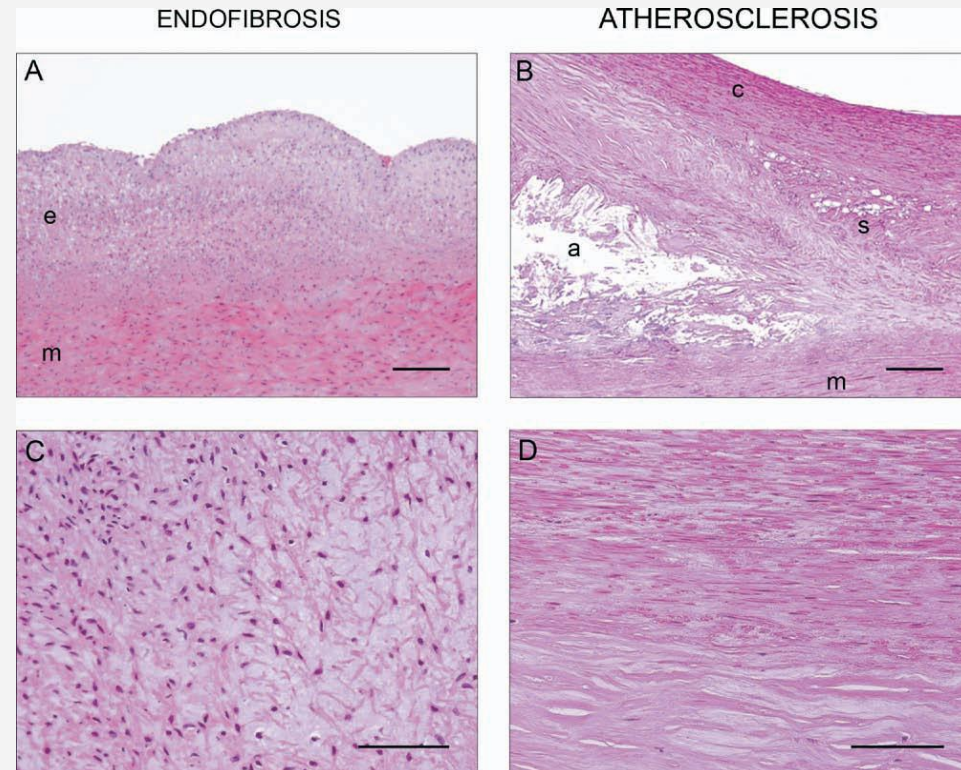
- 90% EIA
- 15% bilateral
- Eccentric plaque
- 2 - 6cm length
- Extension to CFA





Pathology

- Distinct from atherosclerosis
- Subintimal thickening
- Accumulation of loose connective tissue
- Natural history poorly understood



Reduction in arterial flow

- Luminal narrowing
- Kinking
- Combination

Symptoms

- Delayed presentation
- Unilateral
- Weakness / lack of power
- Numbness / paraesthesia
- Swelling
- Cramp
- Acute presentation unusual

Clinical signs

- Clinical examination
invariably normal
- Bruit on hip flexion
+ve LR 2.17
- Bruit on hip extension
+ve LR 6



Diagnostic value of specific history

Test Variable	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Disappearance of complaint in less than 5mins of rest	0.97	0.29	0.70	0.83
Progression of the complaint	0.79	0.53	0.74	0.60
Symptoms in >3 muscles (out of 6)	0.48	0.94	0.93	0.52
Symptoms in >3 muscles + calf pain + iliofemoral bruit	0.90	0.50	-	-

Investigations

- ABPI

Exercise tests

Provocative tests

- Duplex ultrasound

During exercise

Dynamic (hip flexion)

- MR angiography

Angiography

Dynamic (hip flexion)

GTN



Natural history

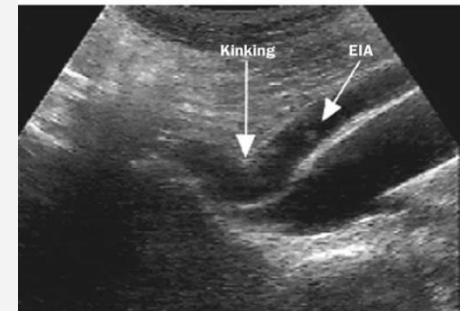
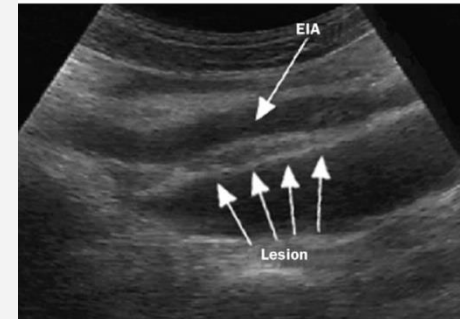
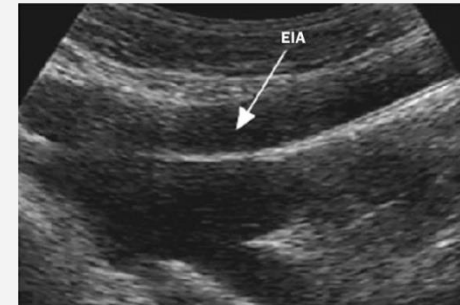
- Symptoms often appear at specific times
- Time trialling / interval training
- Stable / progressive
- No improvement
- Increasing numbers of dissections / occlusions

Diagnostic utility of post-exercise testing using Doppler ultrasound

Test Variable	Sensitivity	Specificity	Positive predictive value	Negative predictive value
Inter-ankle pressure difference >23mmHg (1min post exercise)	0.73	0.95	0.97	0.61
Reduced ABPI during first 5 minutes post-exercise	1.0	1.0	-	-
ABPI <0.66 at 1min after max exercise	0.90	0.87	-	-
ABPI <0.48 1 minute after max exercise	0.80	1.0	-	-
Inter-ankle pressure difference >22mmHg During first 4 mins after exercise	0.93	0.93	0.93	0.93
Inter-ankle ABPI difference >0.1 during first 4 mins after exercise	0.90	0.95	0.95	0.90

Duplex ultrasound

- Normal EIA (increased IMT common)
- Smooth non calcified endofibrotic plaque located on the dorsal side of the external iliac artery
- Bending common but kinking (haemodynamic changes) of external iliac artery with hip flexed unusual



ASYMPTOMATIC SIDE

SYMPTOMATIC SIDE

27360920131216

St Georges Hospital

C5-1/Abd Vasc

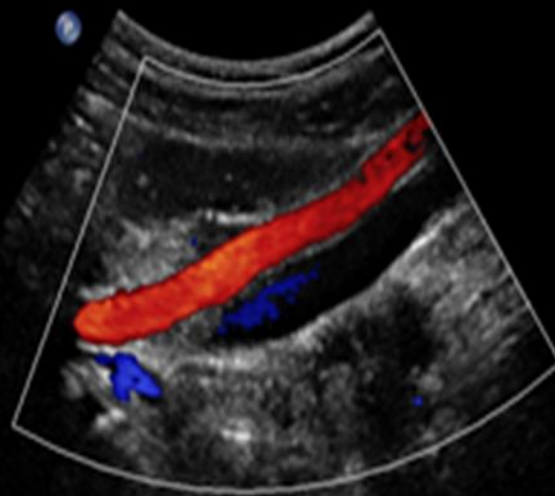
27360920131216

St Georges Hospital

C5-1/Abd Vasc

PRE EXERCISE

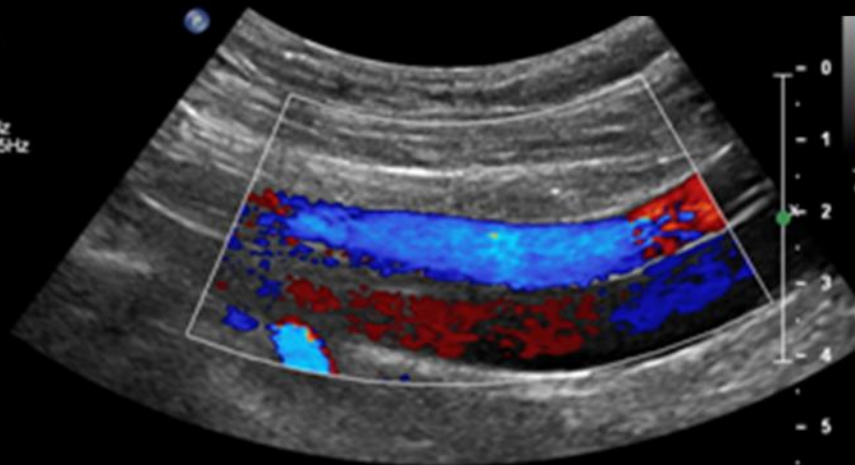
RT EIA



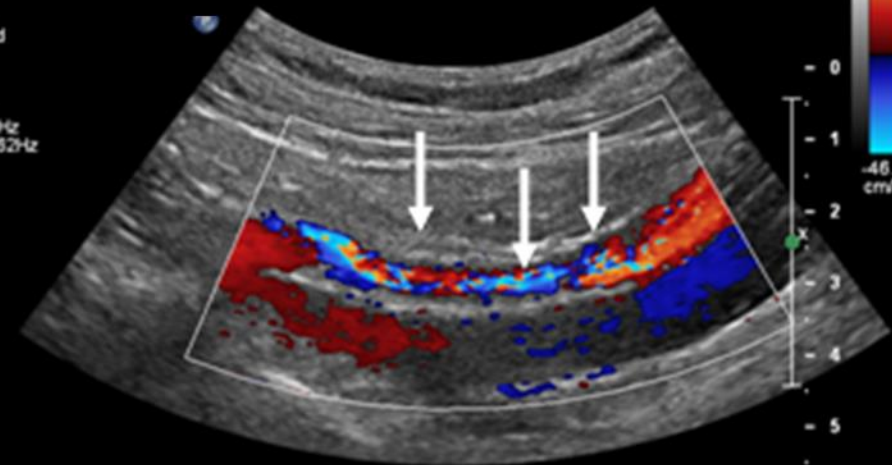
LT EIA



RT EIA

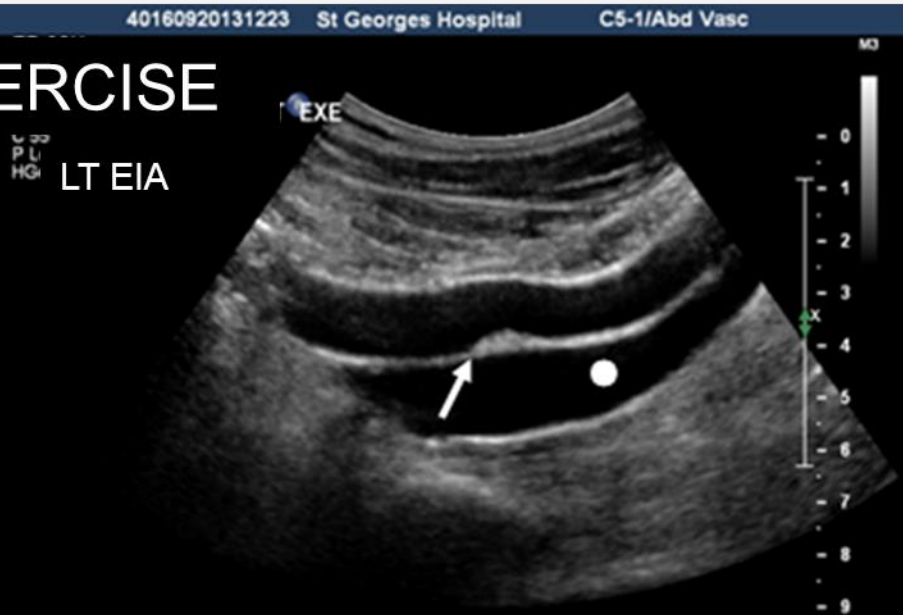
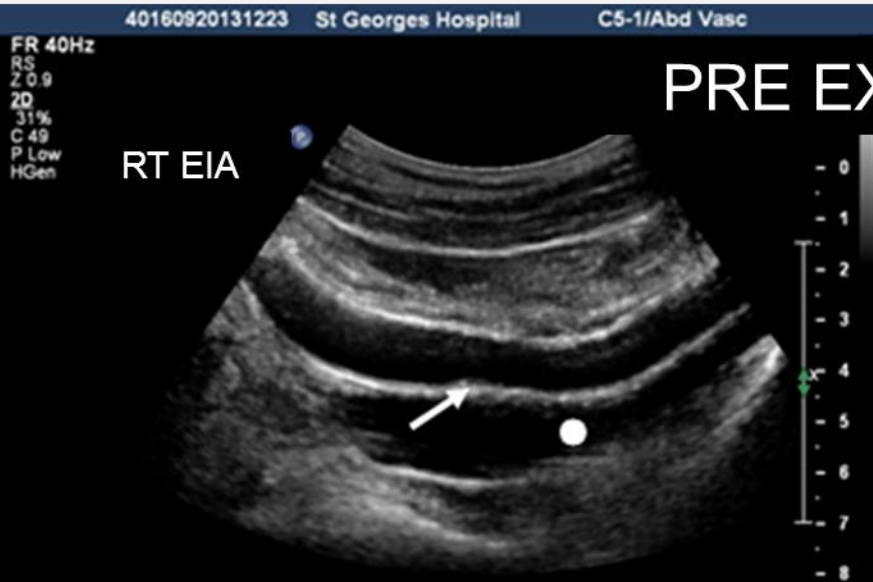


POST EXERCISE



ASYMPTOMATIC SIDE

SYMPTOMATIC SIDE



POST EXERCISE

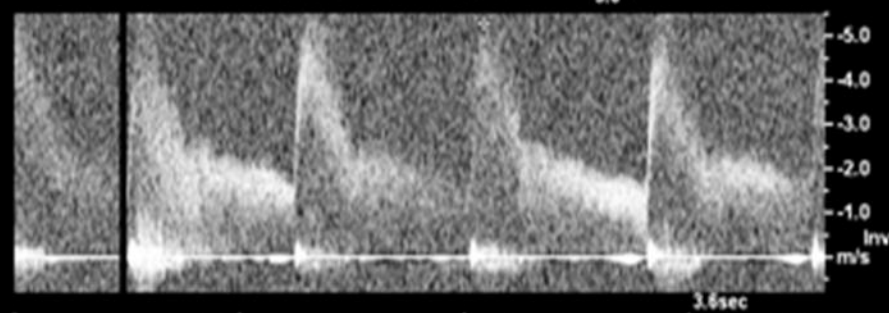
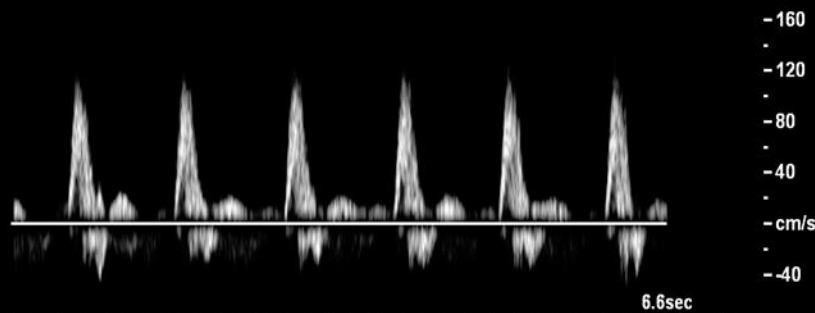
PW
40%
WF 100Hz
SV2.0mm
M3
2.3MHz
3.1cm

-38.5
cm/s

LT EIA

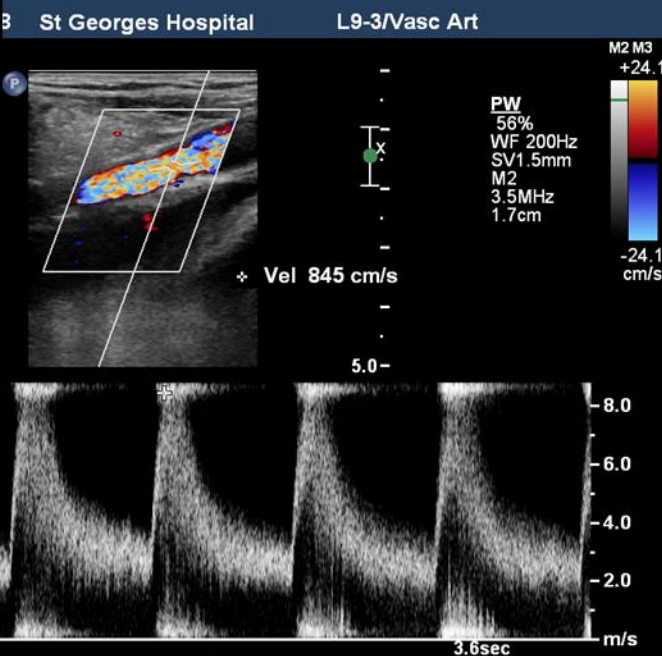
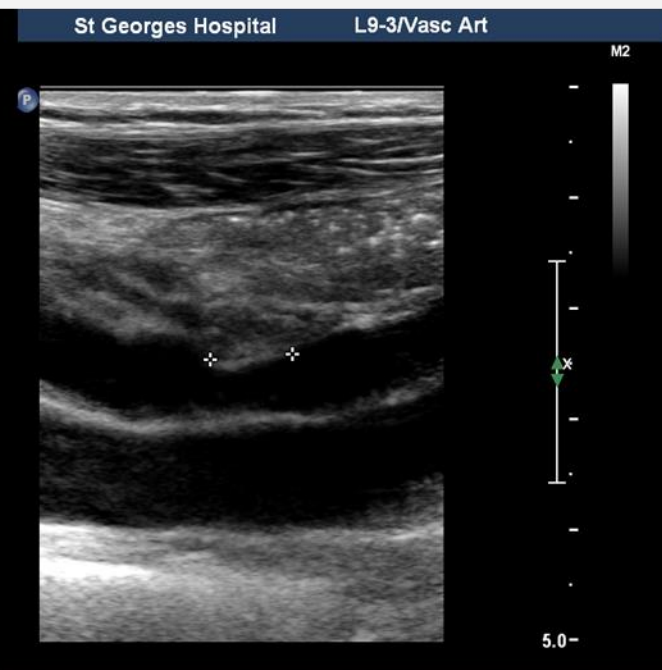
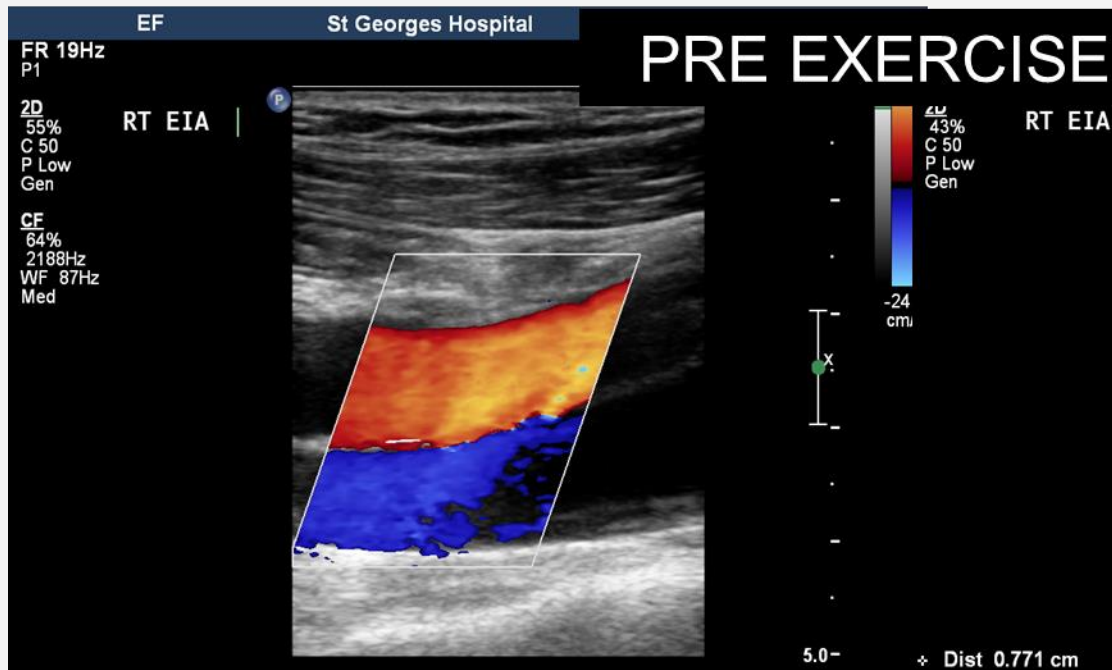
2D
51%
C 50
P Low
Gen

CF
64%
2188Hz
WF 87Hz
Med



ASYMPTOMATIC SIDE

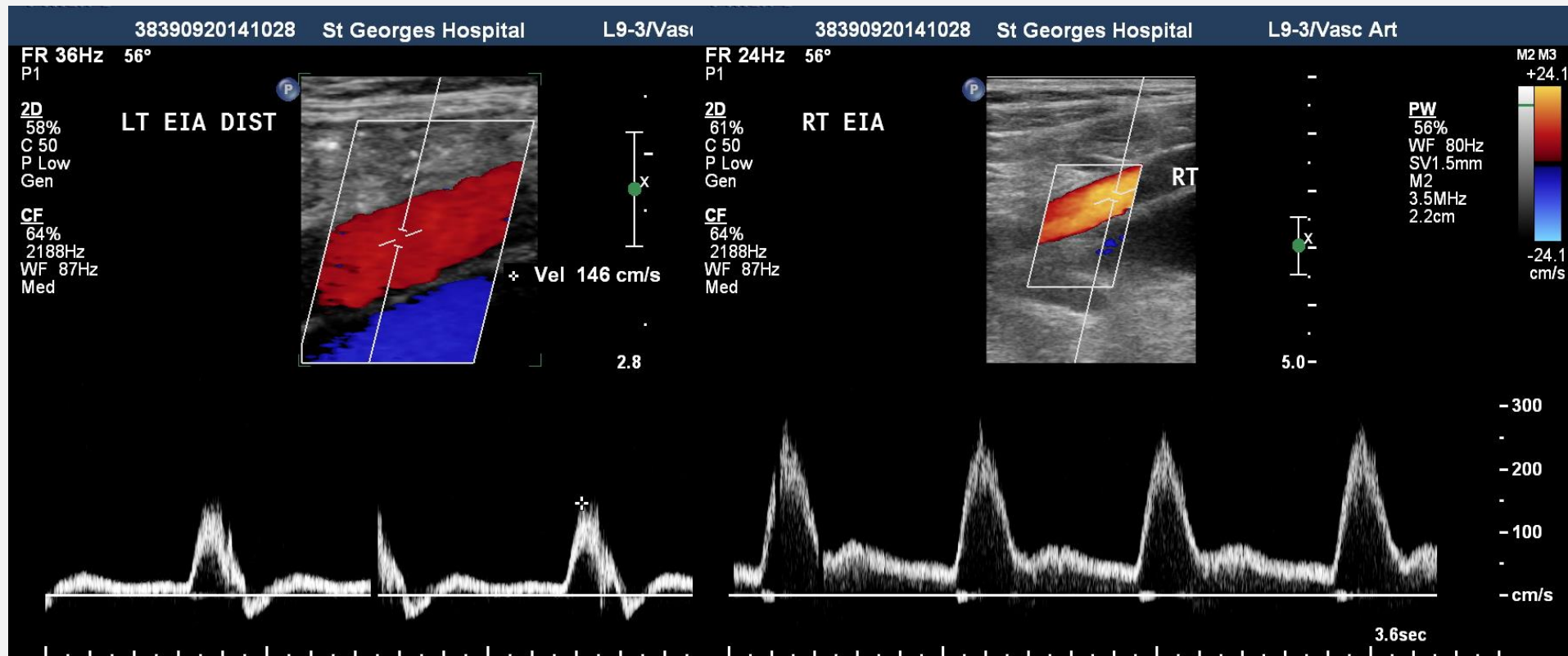
SYMPTOMATIC SIDE



AT REST WAVEFORMS

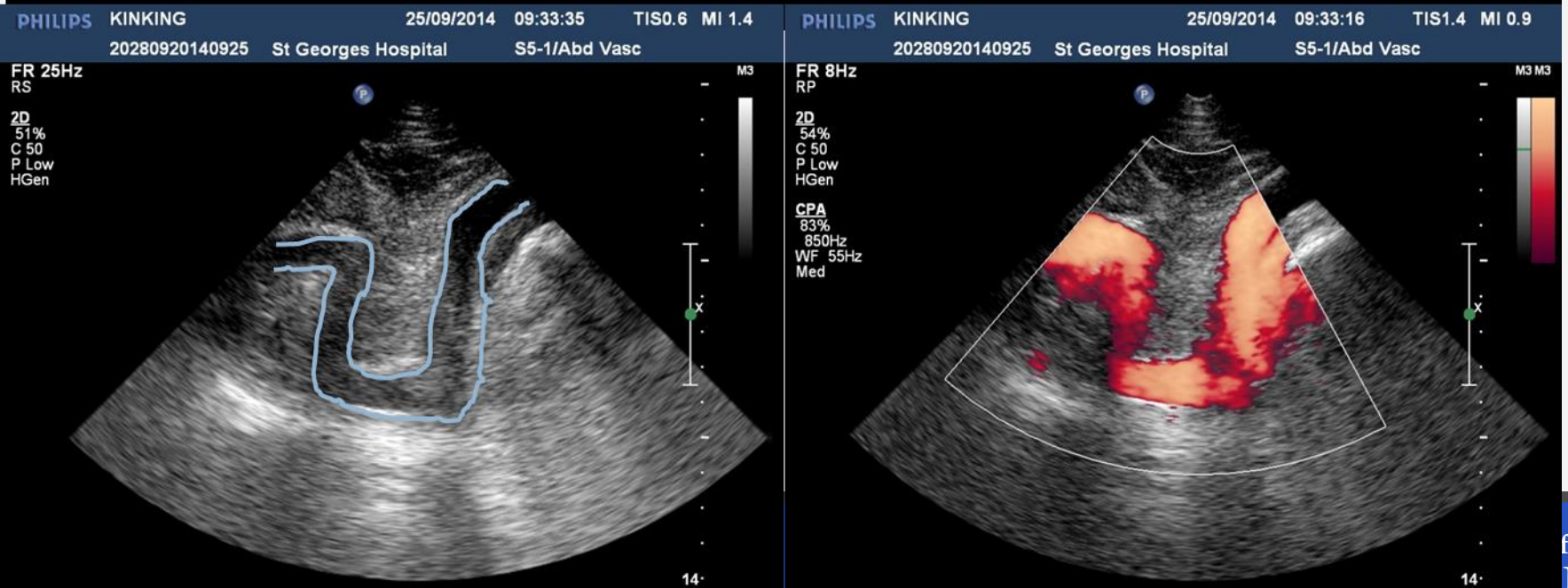
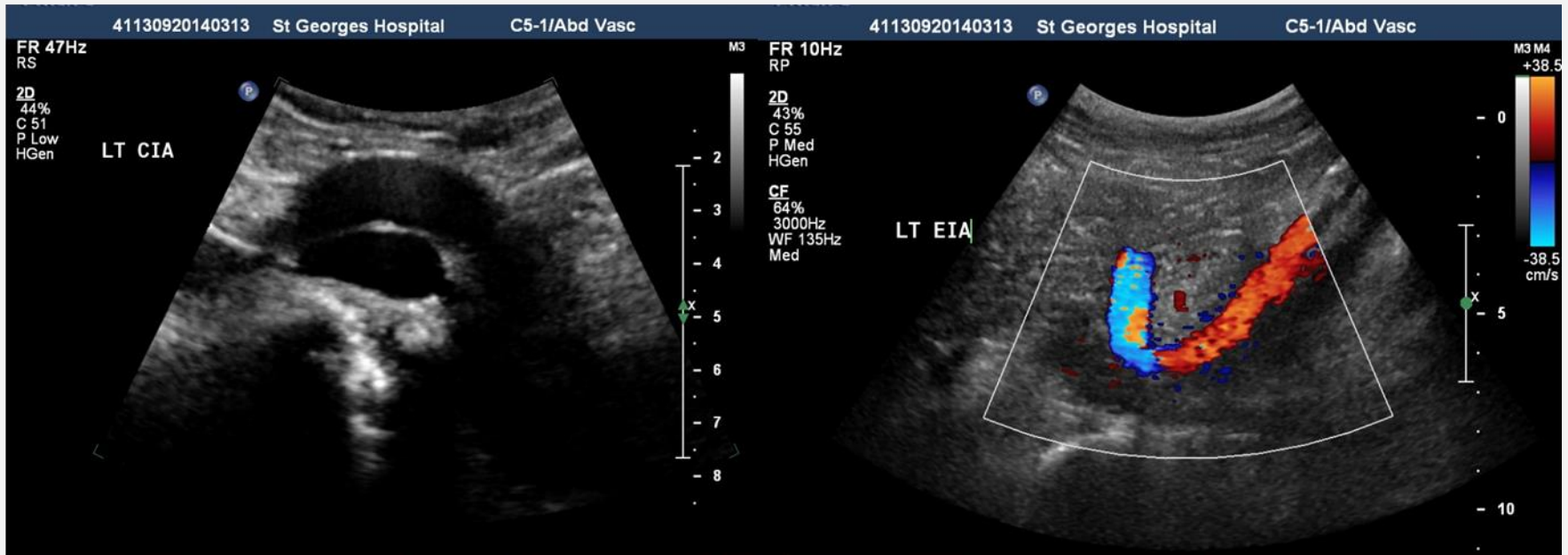
ASYMPTOMATIC SIDE

SYMPTOMATIC SIDE



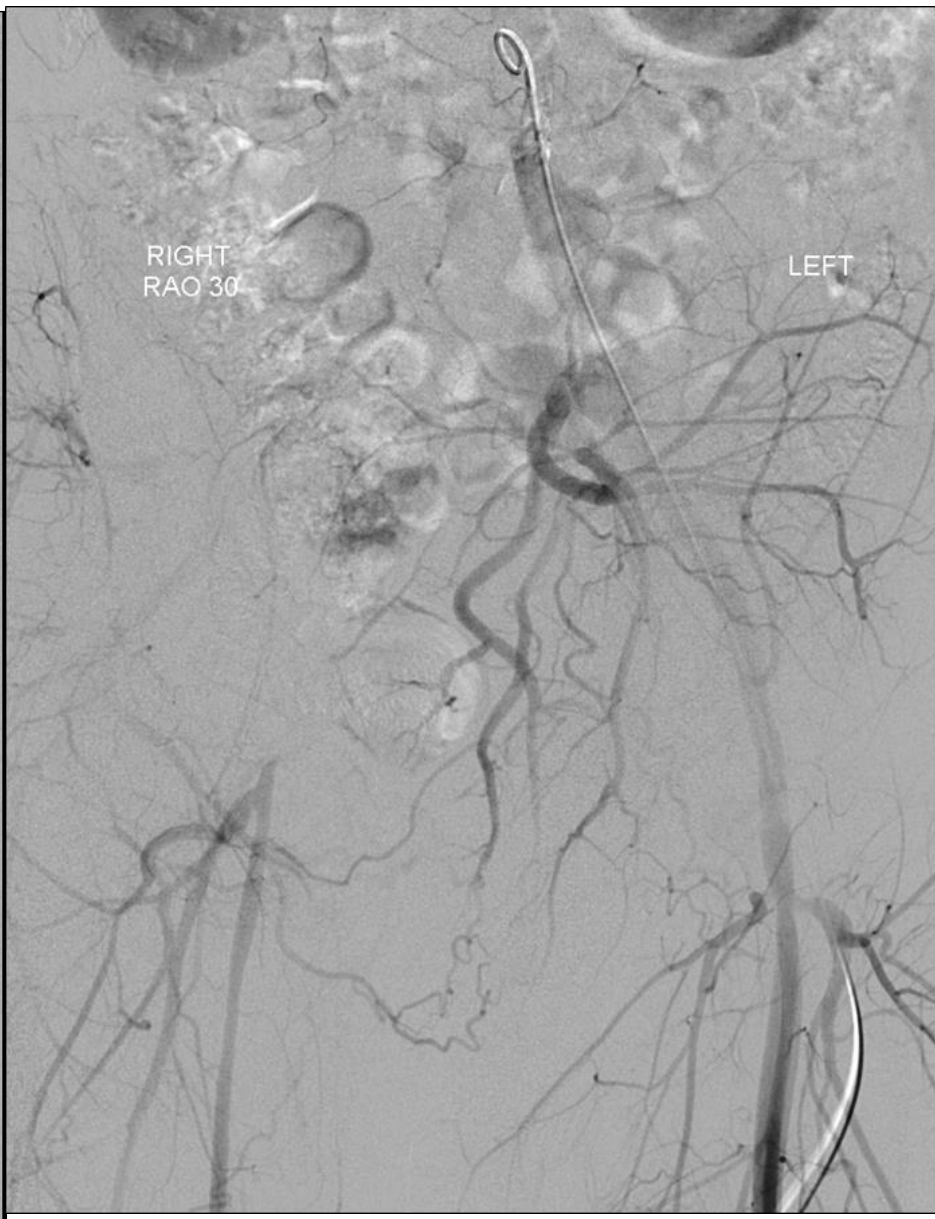
Reduced arterial compliance

COMMON TORTUOUSITIES OBSERVED IN THE EF









Management

- Change cycling position
- Different sport
- Conservative
- *Angioplasty / stent*
- Surgery



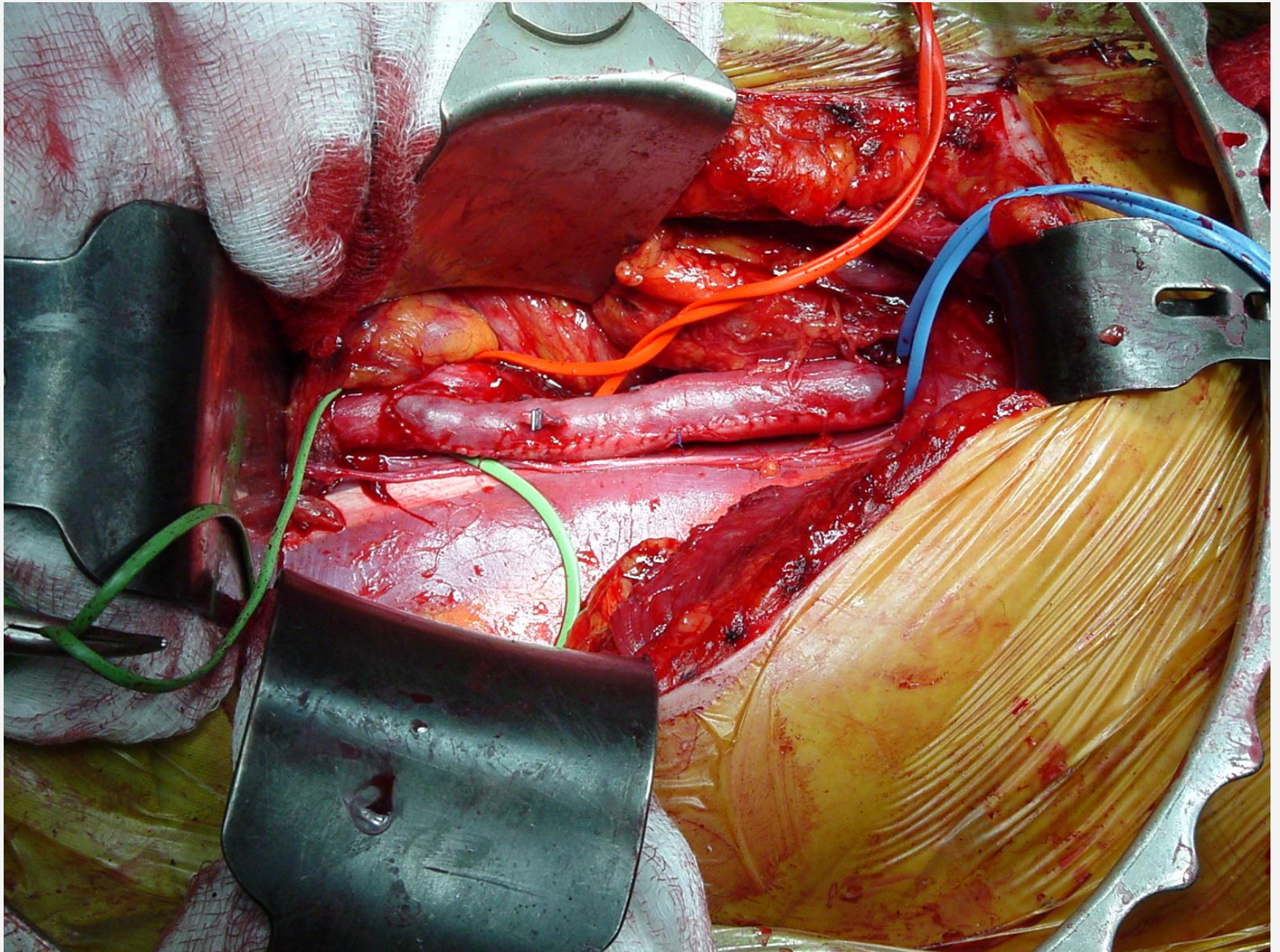
Management

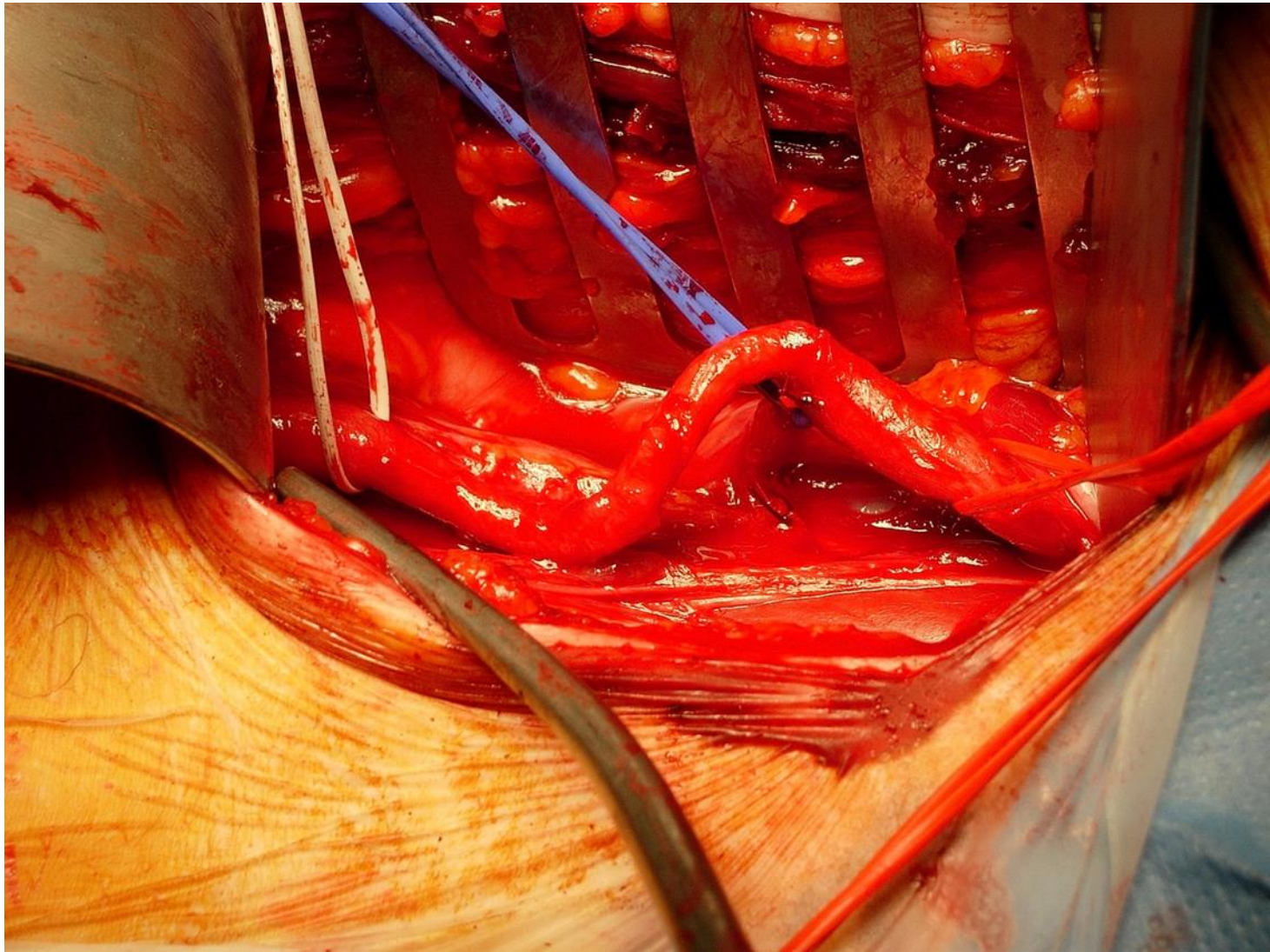
- Change cycling position
- Different sport
- Conservative
- *Angioplasty / stent*
- Surgery

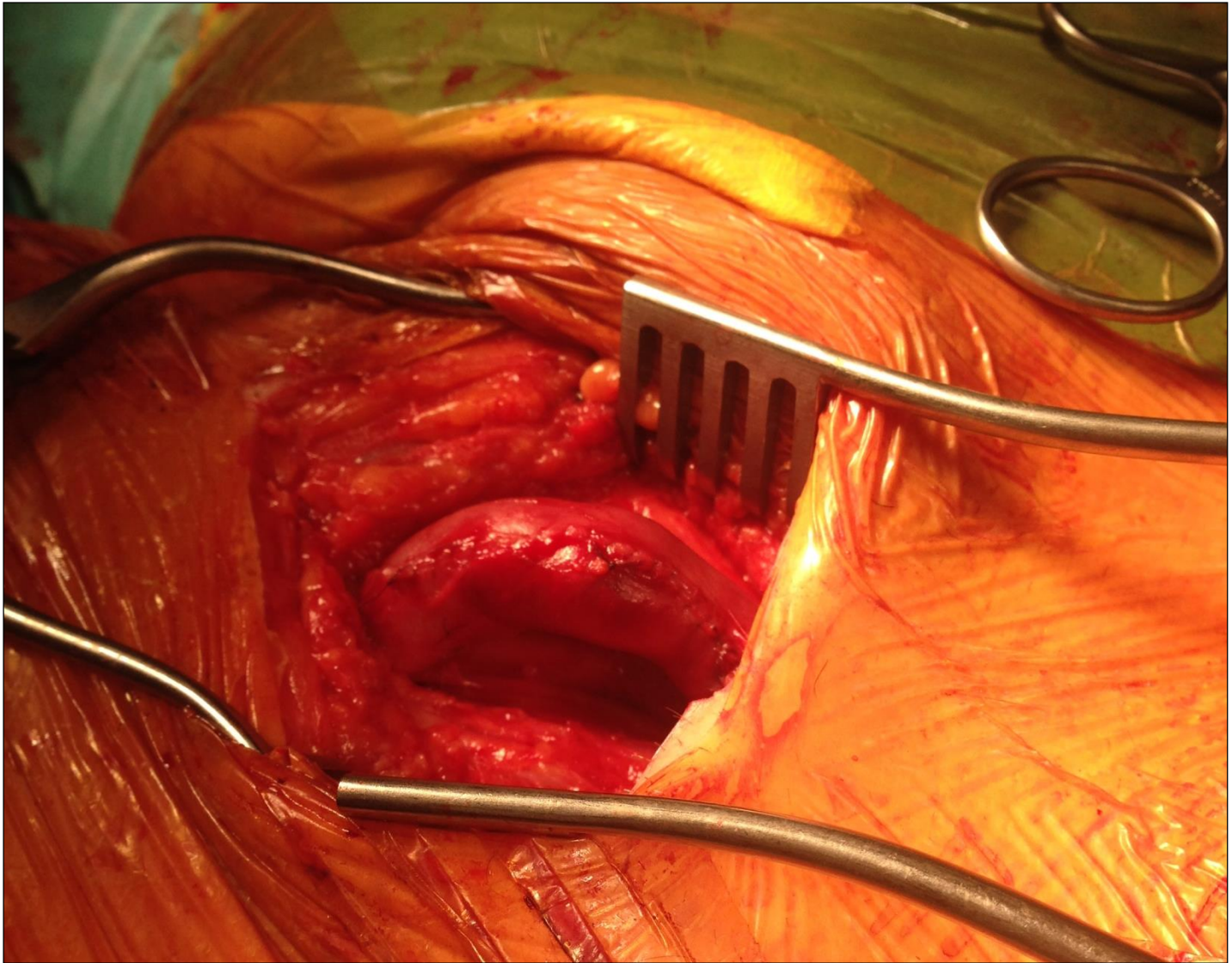


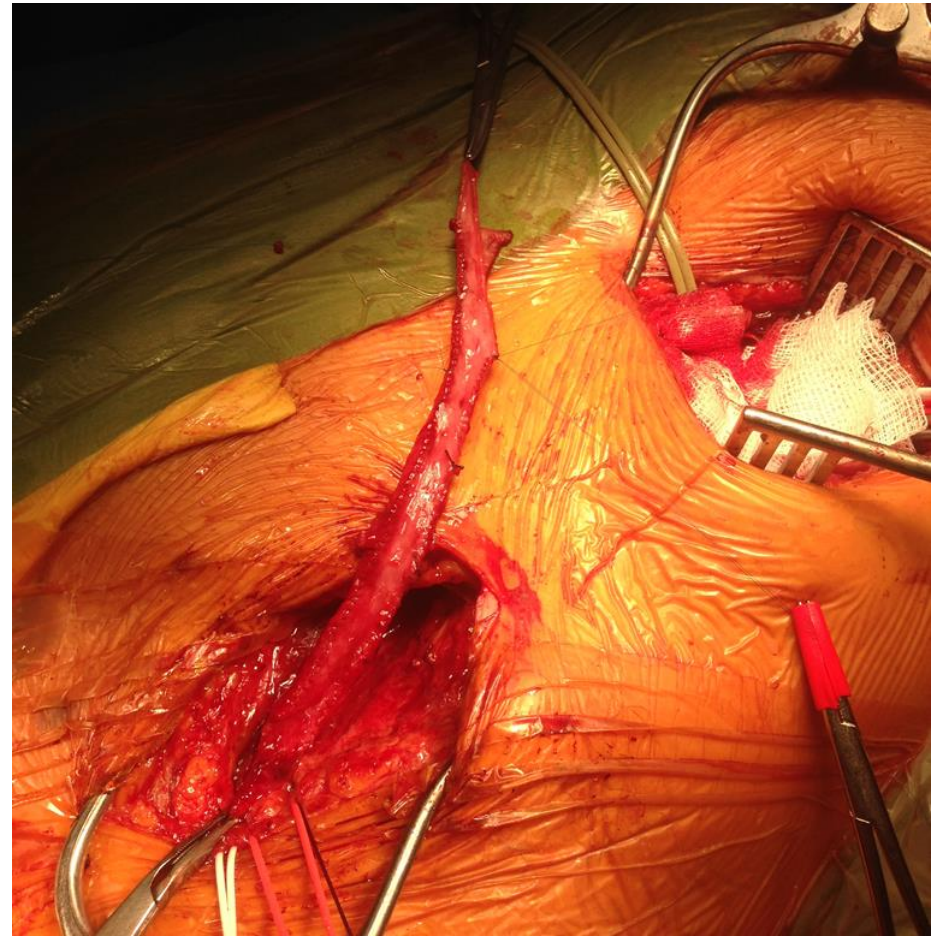
Surgical options

- Arterial release
(for kinking only and must exclude luminal narrowing)
- Arterial shortening
(kinking and arterial redundancy)
- Endarterectomy and vein (prosthetic) patch angioplasty
- Resection of fibrotic segment and saphenous vein interposition (diameter may require panel graft)
- *Prosthetic graft*
- *Inguinal ligament release in combination*









Results

- Arterial release

Schep (2002)

n=23 - 53% symptom free

- Endofibrosectomy + arterial shortening / saphenous bypass

Feugier (2004)

n=350 - 5 persistent symptoms

332 returned to sport

Alimi (2004)

n=14 - 12 symptom free



Conclusions

- Increasing prevalence
- Often dismissed / inappropriately managed
- Exercise test key in diagnosis
- Angiograms often normal
- Natural history uncertain (increasing number dissections)
- Outcomes from surgery encouraging (avoid angioplasty / stents / shortening alone)

