EVALUATION OF THE ATHLETE WITH EXERTIONAL LEG PAIN

UNITED STATES
OLYMPIC & PARALYMPIC
COMMITTEE

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Disclosures

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  - Royalties – Springer, Up to Date

Case - History

19 y/o female collegiate soccer (football) player

3 year history of bilateral anterolateral leg pain

- Aching, burning, pressure
- 0-10/10 in severity
- Increased with running
- Absent at rest and with normal, daily activities
- Associated with numbness, tinging, weakness

Treatments: activity modification, physical therapy, physical modalities, NSAIDS, massage, acupuncture, chiropractics

No significant PMHx/PSHx

Case – Physical Examination

Healthy, athletic appearance

Normal gait pattern

Normal neurologic examination

No TTP

Normal peripheral pulses

Case – Differential Diagnosis

Bone/periosteum
- Medial tibial stress syndrome
- Stress fracture

Muscle/tendon
- Muscle strain
- Tendinitis/tendinosis

Peripheral nerve
- Superficial peroneal nerve
- Saphenous nerve

Infection

Vascular
- Popliteal artery entrapment syndrome (PAES)
- Endofibrosis (e.g. external iliac artery)

Chronic exertional compartment syndrome

Referred
- Proximal nerve entrapment
- Joint

Neoplasm

CECS - Epidemiology

Often bilateral (up to 82%)[22]

No gender predilection

Frequently occurs in conjunction with other diagnoses

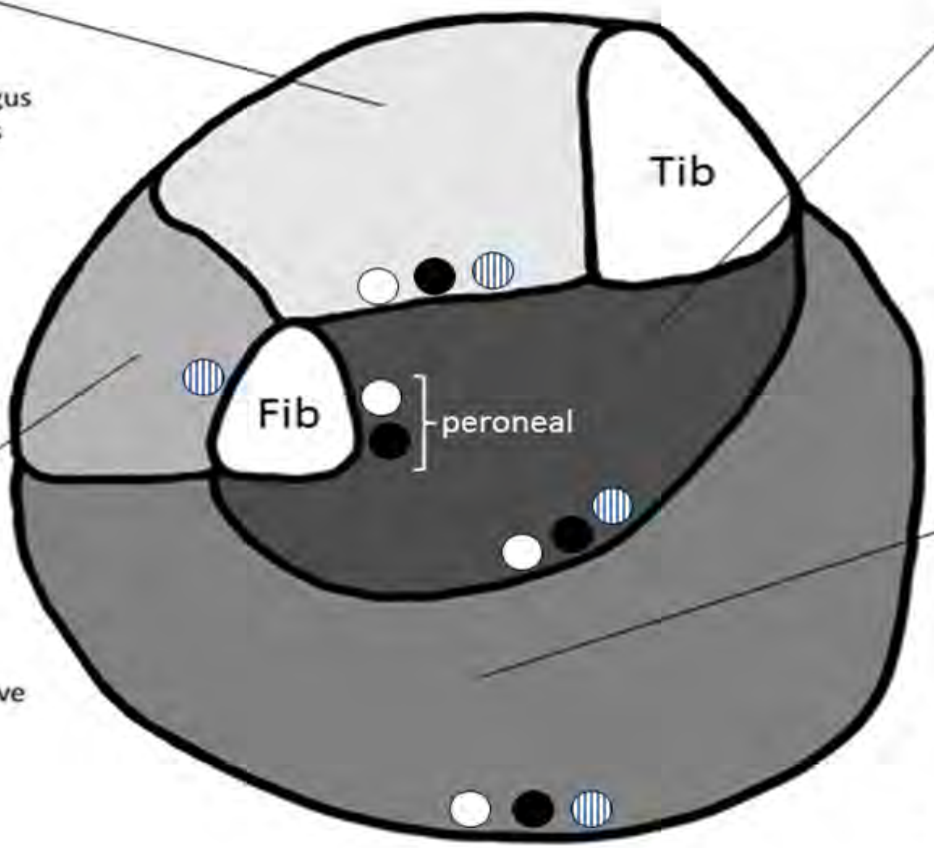
- MTSS
- Vascular insufficiency (e.g., PAES + CECS = 51%)[35]
- Nerve entrapment

CECS - Anatomy

Anterior > deep posterior > lateral > superficial posterior

Anterior Compartment
- Muscles
  - Tibialis anterior
  - Extensor digitorum longus
  - Extensor hallucis longus
  - Peroneus Tertius
- Vessels
  - Anterior tibial artery
  - Anterior tibial vein
- Nerve
  - Deep peroneal nerve

Lateral Compartment
- Muscles
  - Peroneus Longus
  - Peroneus Brevis
- Nerve
  - Superficial peroneal nerve



Deep Posterior Compartment
- Muscles
  - Flexor digitorum longus
  - Tibialis posterior
  - Flexor hallucis longus
  - Popliteus
- Vessels
  - Posterior tibial artery
  - Posterior tibial vein
  - Peroneal artery
  - Peroneal vein
- Nerve
  - Tibial nerve

Superficial posterior compartment
- Muscles
  - Soleus
  - Gastrocnemius
  - Plantaris
- Vessels
  - Branch of tibial artery
  - Branch of tibial vein
- Nerve
  - Sural nerve

*5th compartment = tibialis posterior[21]

CECS - Etiology

Excessive increase in intra-compartmental pressure during exercise

Results in:

- Decreased mean intra-muscular blood flow
- Decreased intramuscular oxygenation[6]

CECS - History

Cramping, burning, aching, tightness

Begins at a specific intensity/duration of activity

Resolves with rest

Can’t push through the pain

May report weakness, paresthesias in leg and/or foot

CECS – Physical Examination

At rest with no recent exercise

- Normal

Immediately following pain provoking activity, may have:

- Swelling
- Tenderness
- Muscle herniation
- Neurologic deficits

CECS – Diagnostic Studies

Pre- and post-exercise compartment pressure testing Pedowitz Criteria[29]

- Rest > 15 mm Hg
- 1 min post ex > 30 mm Hg
- 5 min post ex > 20 mm Hg

CECS – Diagnostic Studies

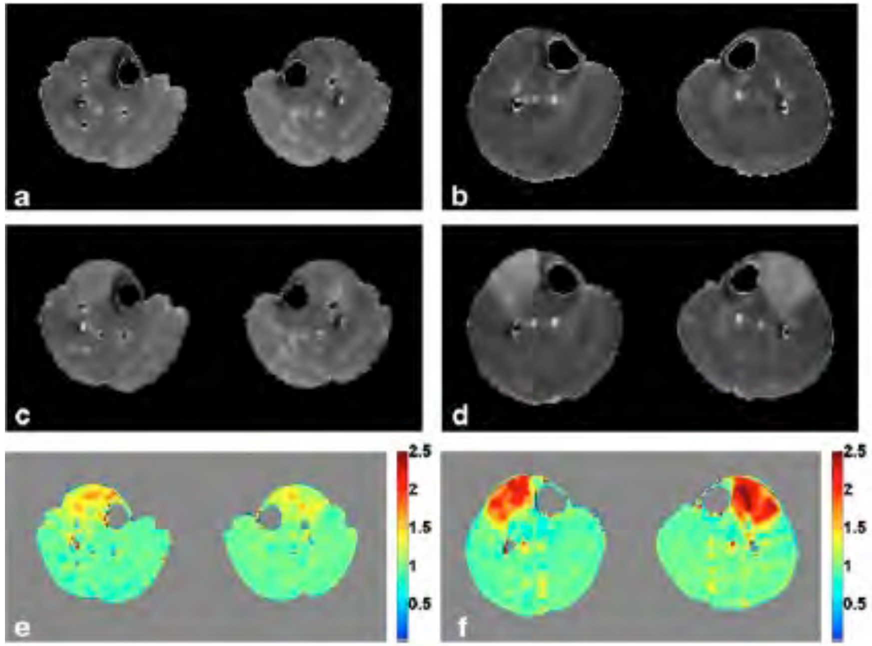
Some question the validity of Pedowitz criteria[18]

- Significant overlap between confidence intervals of health subjects and those with CECS
- Limitations to original study (retrospective, poor selection criteria, lack of standardized exercise and compartment testing protocol, etc)

Proposed changes to the criteria[17]

- Resting > 14
- 1 min post-ex > 36
- 5 min post-ex > 23

CECS – Diagnostic Studies



Amrami MRI protocol[7] for anterior compartment CE

- Dual birdcage coil and in-scanner exercise protocol
- 42 patients, 14 with CECS
- 96% sensitivity
- 90% specificity
- 96% accuracy

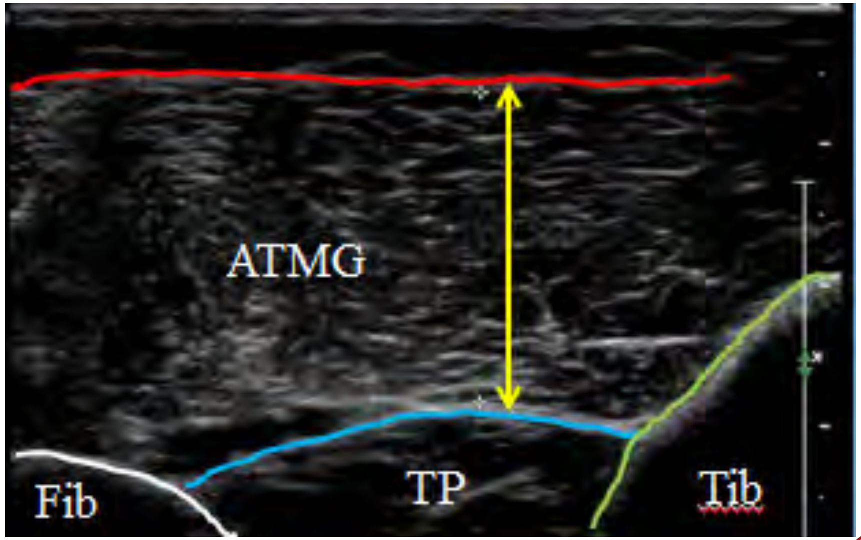
Follow-up study[19]

- 76 patients, 23 with CECS
- 96% sensitivity
- 87% specificity

CECS – Diagnostic Studies

Rajasekaran ultrasound protocol

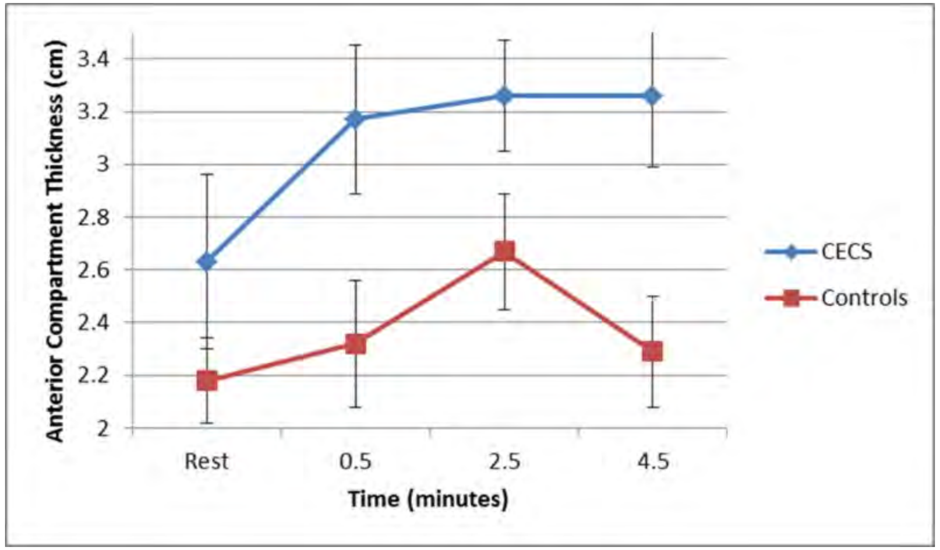
- Compared pre- and post-exercise anterior compartment thickness in patient's with CECS to controls

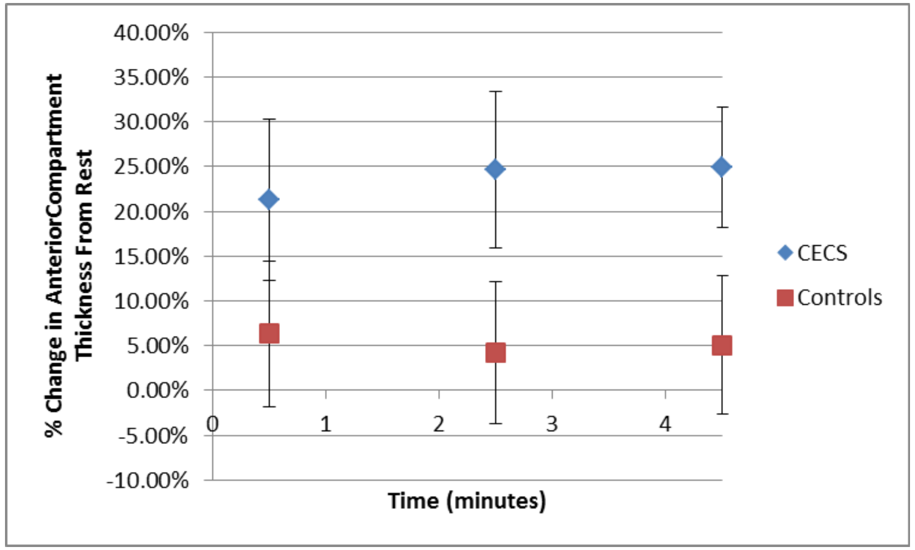


CECS Diagnostic Studies

Rajasekaran ultrasound protocol

- > 15% increase in post-exercise anterior compartment thickness in pt's with CECS compared to controls





CECS - Treatment

Forefoot running[20]

- Decreases post-exercise anterior compartment pressures and pain

Fasciotomy

- Return to full sports 8-12 wks
- Success rate
  - 30% deep posterior
  - 80% anterior
- Complications = 16%
  - Infection, hematoma, NV injury, DVT, lymphocele

CECS Treatment – Botulinum Toxin A

Botulinum toxin is produced by gram-positive anaerobic bacterium Clostridium botulinum

- 7 neurotoxins (A,B,C, etc)

4 FDA approved types of botulinum toxin

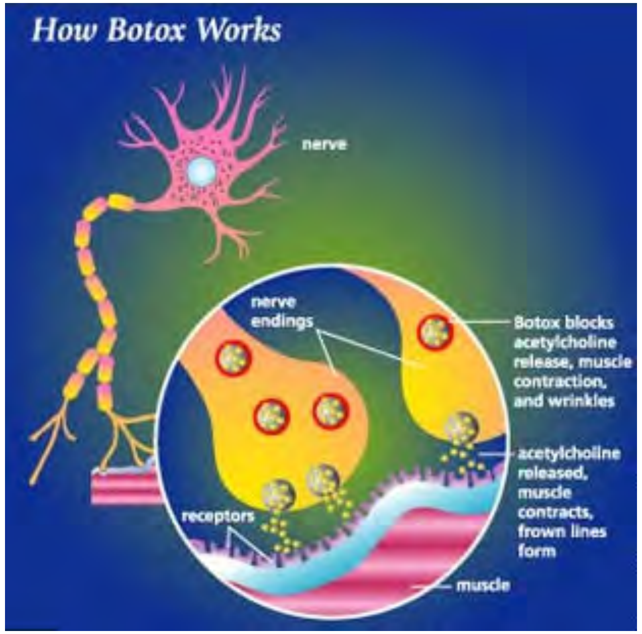
- Onabotulinum Toxin A: Botox®, Botox Cosmetic®
- Abobotulinum Toxin A: Dysport®
- Incobotulinum Toxin A: Xeomin®
- Rimabotulinum Toxin B: Myobloc®

None are FDA approved for the treatment of exertional leg pain

CECS Treatment – Botulinum Toxin A

Mechanism of Action

- Binds to pre-synaptic nerve terminals
- Blocks release of acetylcholine preventing muscle contraction
- Recover neuromuscular function due to collateral sprout formation and reinnervation over 6-9 months

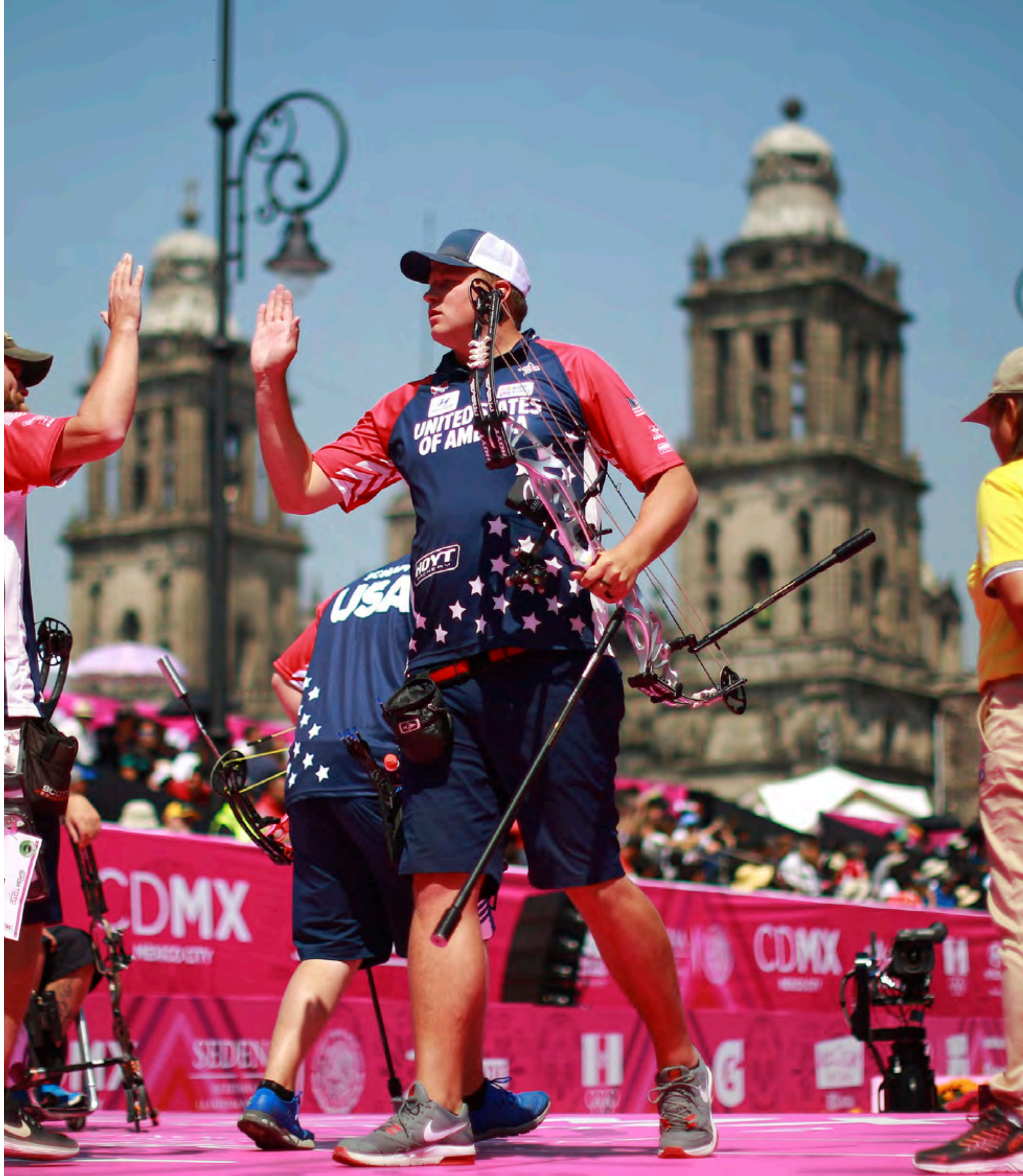


https://microbewiki.kenyon.edu/images/5/52/Info-botox2.jpg

CECS Treatment – Botulinum Toxin A

Adverse events

- **<u>Respiratory depression and death</u>**
- Dysphagia
- Seizures
- Flulike syndrome
- Facial and other muscle weakness



CECS Treatment – Botulinum Toxin A

Three studies[24,28,30]

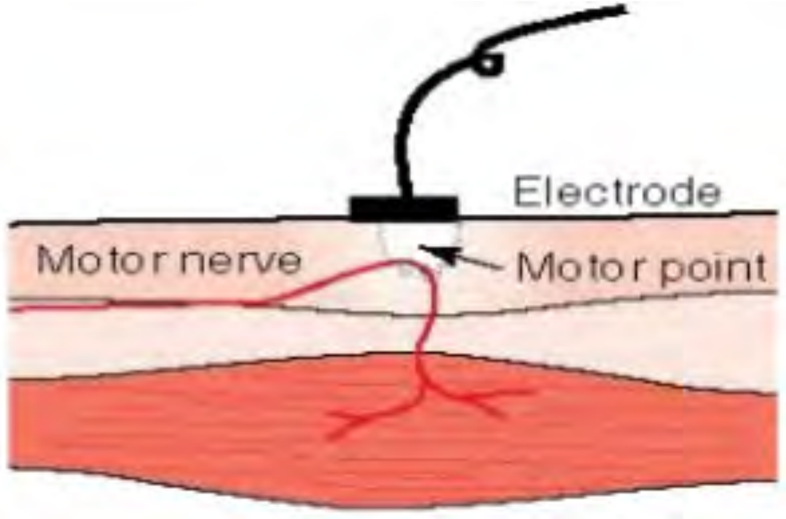
– Rationale
  - Botulinum toxin A has been used to treat muscle hypertrophy and myofascial pain, so…
  - Why not CECS?

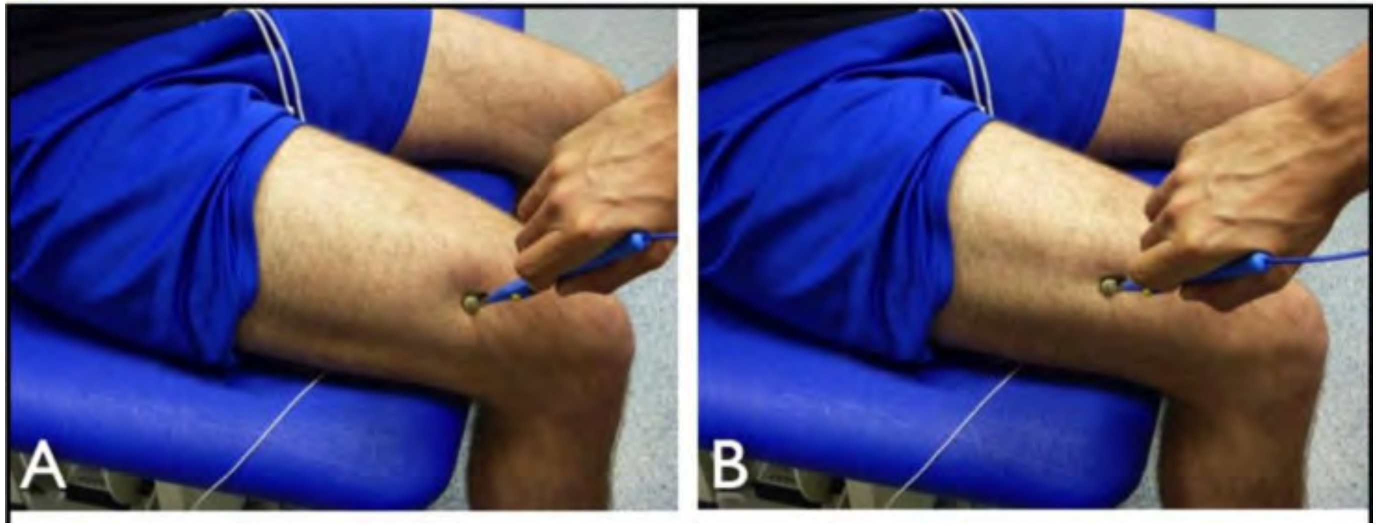
– Tx: Abobotulinum toxin A (Dysport®) was injected into muscles of pathologic compartments
  - Injections guided by electrical stimulation

CECS Treatment – Botulinum Toxin A

Motor point = point where motor nerve enters muscle

Minimal electrical stimulation causes muscle contraction





Gobbo et al. 2014

CECS Treatment – Botulinum Toxin A

http://www.lemg.org/electrodes/needle-electrode/

CECS Treatment – Botulinum Toxin A

Results:

- 1 month
  - Most have 100% relief
  - Some have partial relief
- 3 & 5 months
  - Improvements persist
  - Some weakness (4/5) in treated muscles
    - Improves over time

CECS Treatment – Botulinum Toxin A

Summary

- Current literature is promising
- Level 4 and 5 evidence
- Consistently decreases symptoms
  - Duration unknown
- Causes muscle weakness
  - Could this increase injuries in athletes who participate in multi-directional sports (e.g., basketball) or those that take place on an uneven surfaces (e.g., lacrosse)

CECS Treatment – Needle Fenestration

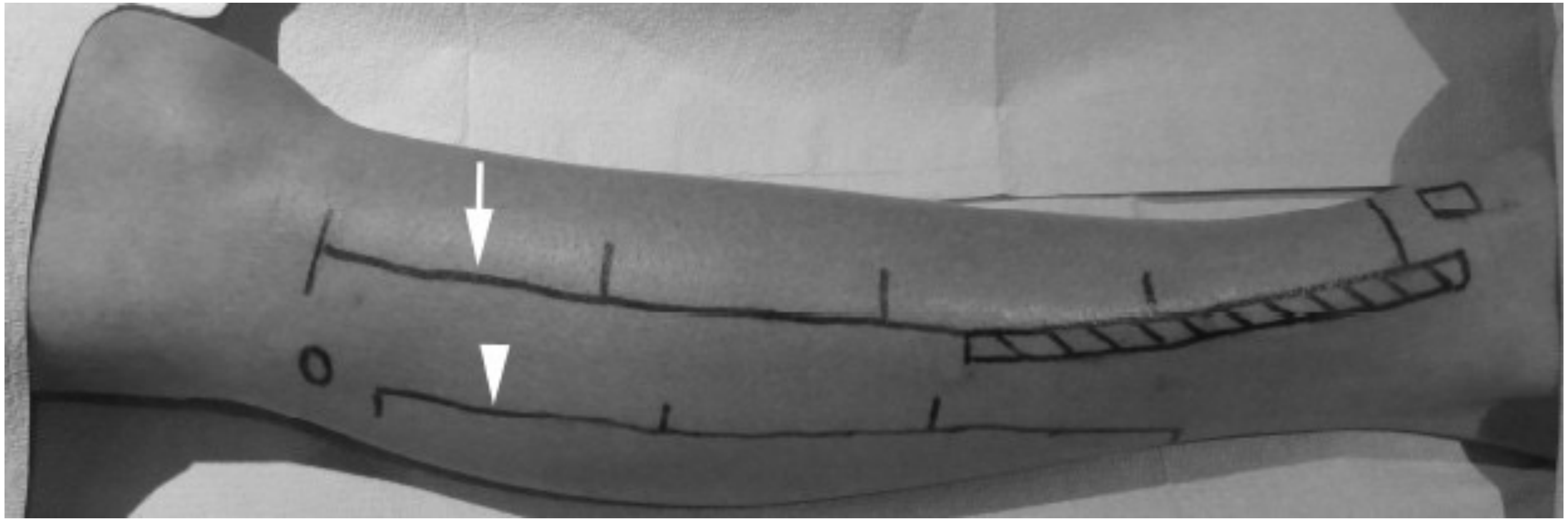
One study[25]

- Rationale
  - Multiple studies have demonstrated successful tx of CTS with US-guided transverse carpal ligament needle fenestration
  - Why not try US-guided needle fenestration of the compartment fascia?
- 18 y/o female collegiate lacrosse player
- 2 yr hx of bilateral anterolateral leg pain
- Dx: bilateral anterior and lateral leg compartment CECS confirmed with
- Tx: US-guided percutaneous needle fenestration

CECS Treatment – US-Guided Needle Fenestration Technique

Pre-scan anterior and lateral compartments

- Identify muscles, nerves, arteries, bony/fascial borders
- Mark superficial locations of nerves, compartment borders
- Mark needle entry levels (every 3 inches from bottom to top of compartment)



Finnoff et al 2015

CECS Treatment – US-Guided Needle Fenestration Technique

Use sterile technique

Transducer

- Anatomic sagittal (anterior compartment) or coronal (lateral compartment) plane

Needle

- In plane relative to the transducer
- Advance proximal to distal

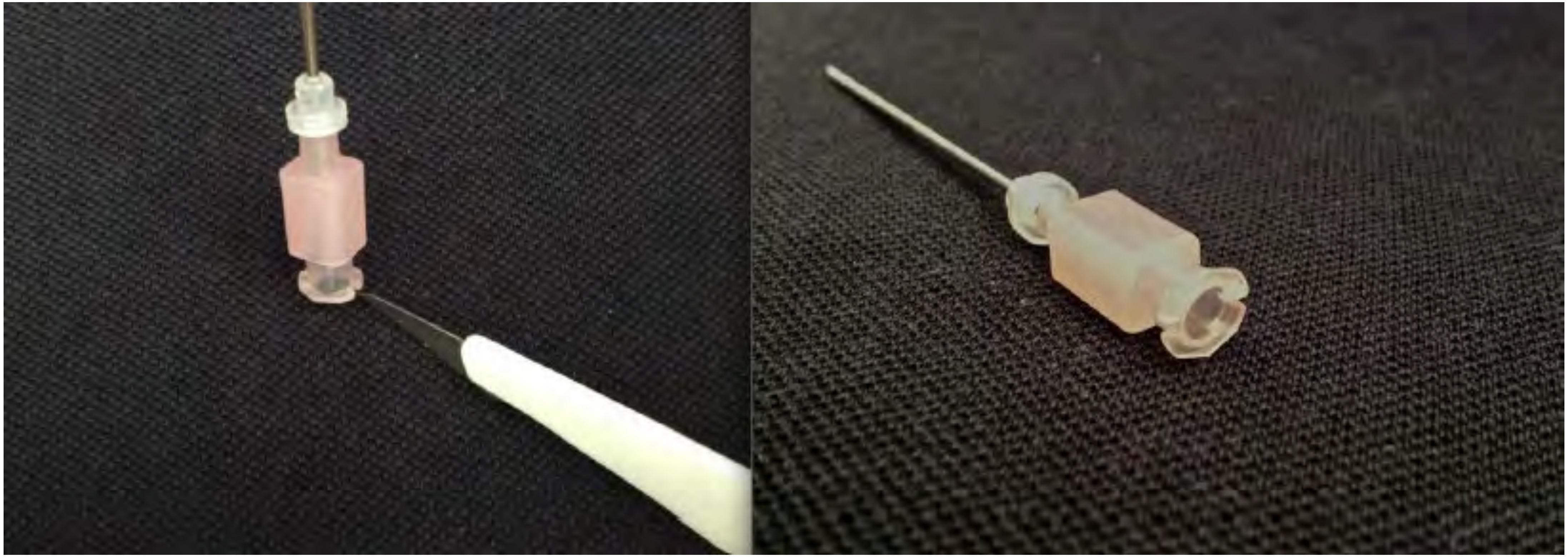
CECS Treatment – US-Guided Needle Fenestration Technique

Anesthetize fascia at each fenestration location with 1% lidocaine using a 22 or 25 gauge, 3.5 inch spinal needle

Repetitively fenestrate fascia with 18 gauge, 3.5 inch spinal needle

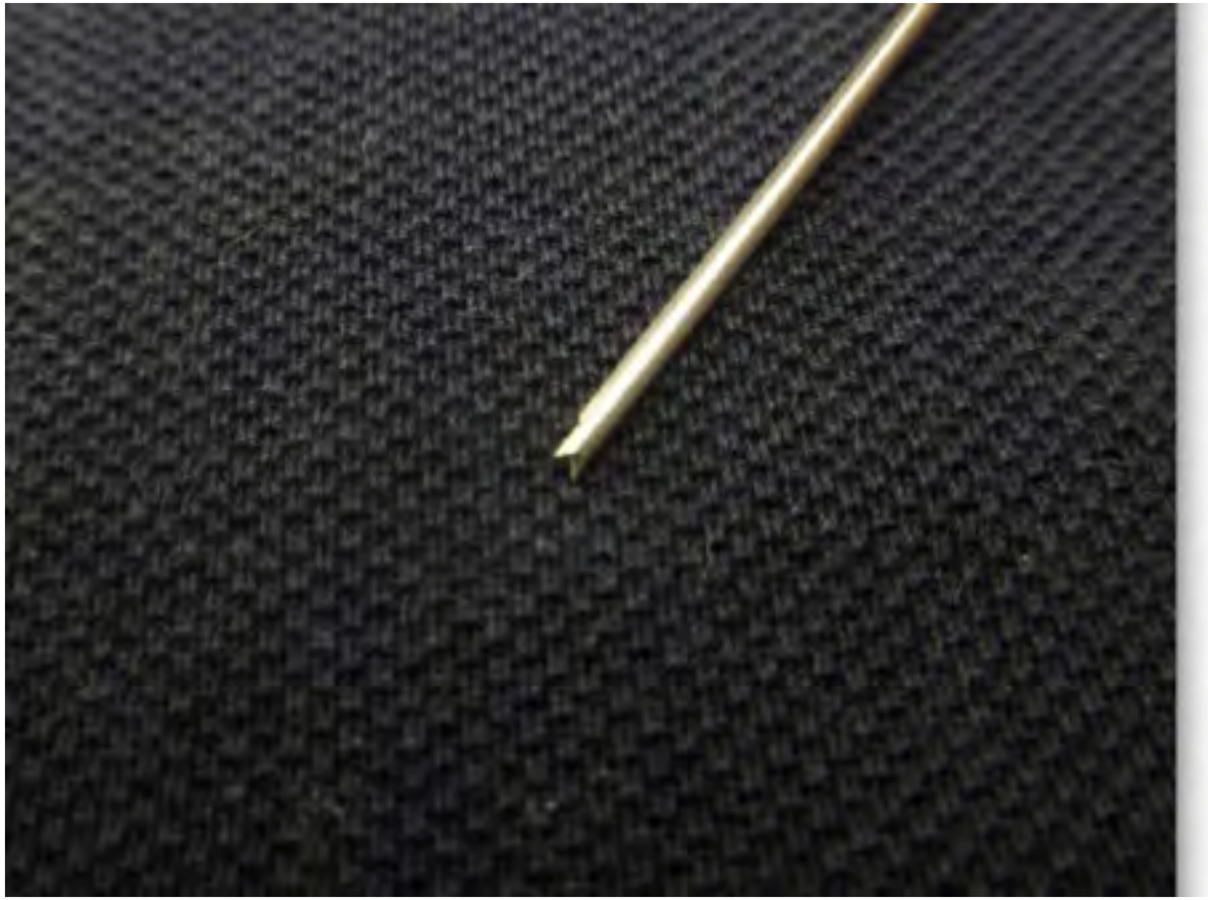
CECS Treatment – US-Guided Needle Fenestration Technique

Consider Hopkins et al.[31] "needle cutter" technique



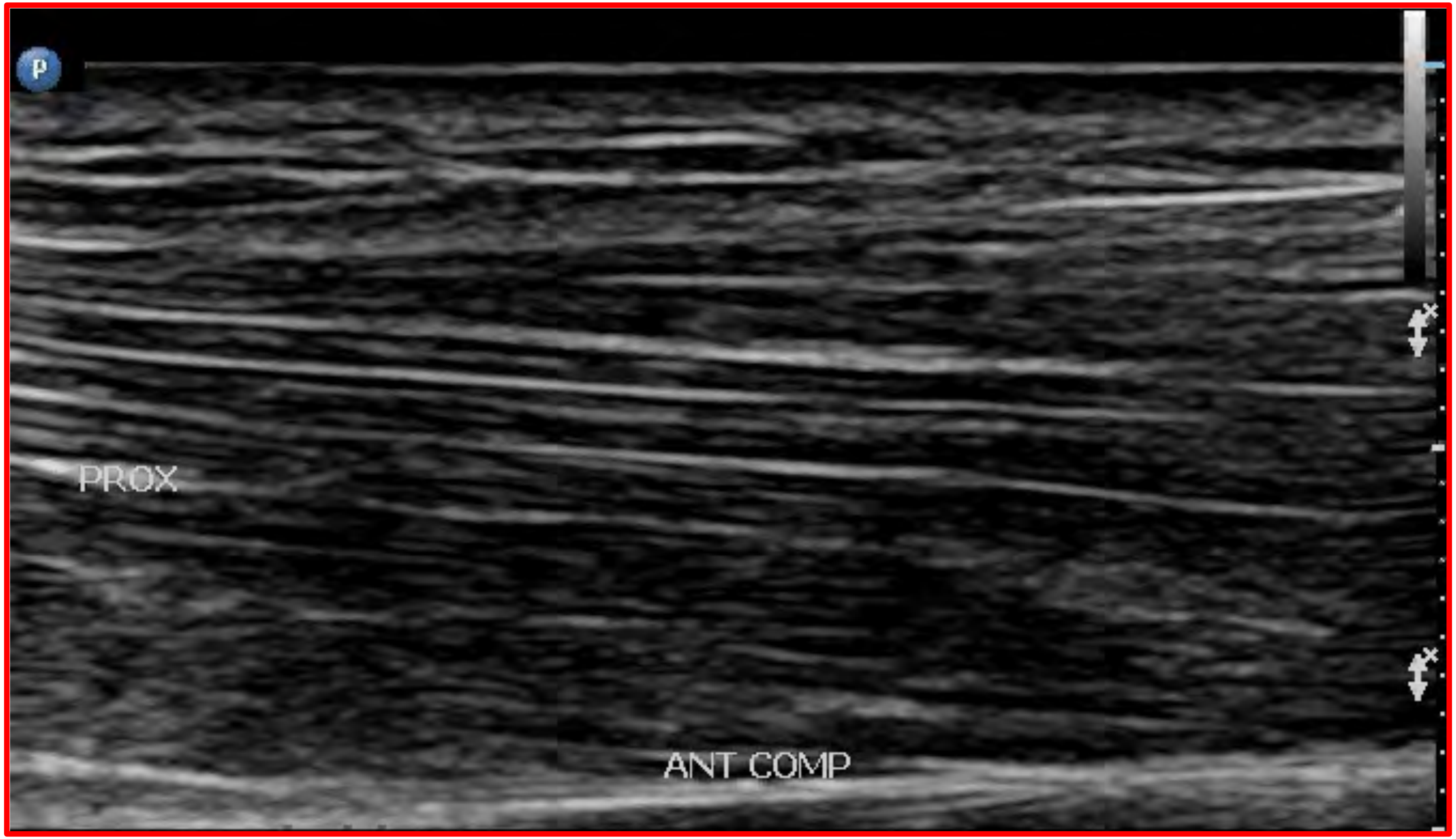
CECS Treatment – US-Guided Needle Fenestration Technique

Consider Hopkins et al.[31] "needle cutter" technique



CECS Treatment – Needle Fenestration

CECS Treatment – Needle Fenestration



CECS - Treatment

CECS Treatment – Needle Fenestration

CECS Treatment – Needle Fenestration

Post-Procedure Protocol

- Rest, ice, compression, AROM x 1 wk
- Begin normal activities 1 wk post-procedure and advance as tolerated

Able to resume collegiate lacrosse

Remained asymptomatic at 18 month follow-up

CECS Treatment – Needle Fenestration

Summary

- Interesting, but…
- Only single case study
- Level 5 evidence

How successful will this be?

- Function
- Duration

CECS Treatment – US-Guided Fasciotomy

Cadaveric Study[32]

- Feasibility/safety study
- 10 unembalmed cadaveric knee-ankle-foot specimens
- 2 sports physicians experienced with US-guided interventions (10 & 5 years, respectively)
- Each performed US-guided fasciotomies of anterior and lateral compartments in 5 cadavers (10 compartments)

CECS Treatment – US-Guided Fasciotomy

Case Study[34]

- 41 y/o female runner 5 month history exertional right leg pain
- Dx: Right leg anterior compartment CECS
- Tx: US-guided fasciotomy
- 1 wk post-procedure, no pain, returned for unrestricted ADL's
- 2 wks post-procedure, had returned to running without pain/activity limitations
- 9 month follow-up = no recurrence or complications

CECS Treatment – US-Guided Fasciotomy

Preliminary safety and efficacy data (unpublished)

- 18 subjects (4 male, 14 female), 50 compartments
- Median age 21.5
- Median follow-up 19 weeks
- Complications = 0
- Median pain during the procedure 3.0
- Median pain 24 hours post-procedure 5.5
- Median days out of school/off work 1.5
- Median days to return to exercise 10

CECS Treatment – US-Guided Fasciotomy

Preliminary safety and efficacy data (unpublished)

- Pain
  - Pre-procedure 8
  - Last follow-up 2 (p = 0.001)
- Global function
  - Pre-procedure 6
  - Last follow-up 9 (p = 0.001)
- Satisfaction
  - Completely satisfied 75%
  - Recommend to a friend/family member = 100% yes

CECS Treatment – US-Guided Fasciotomy

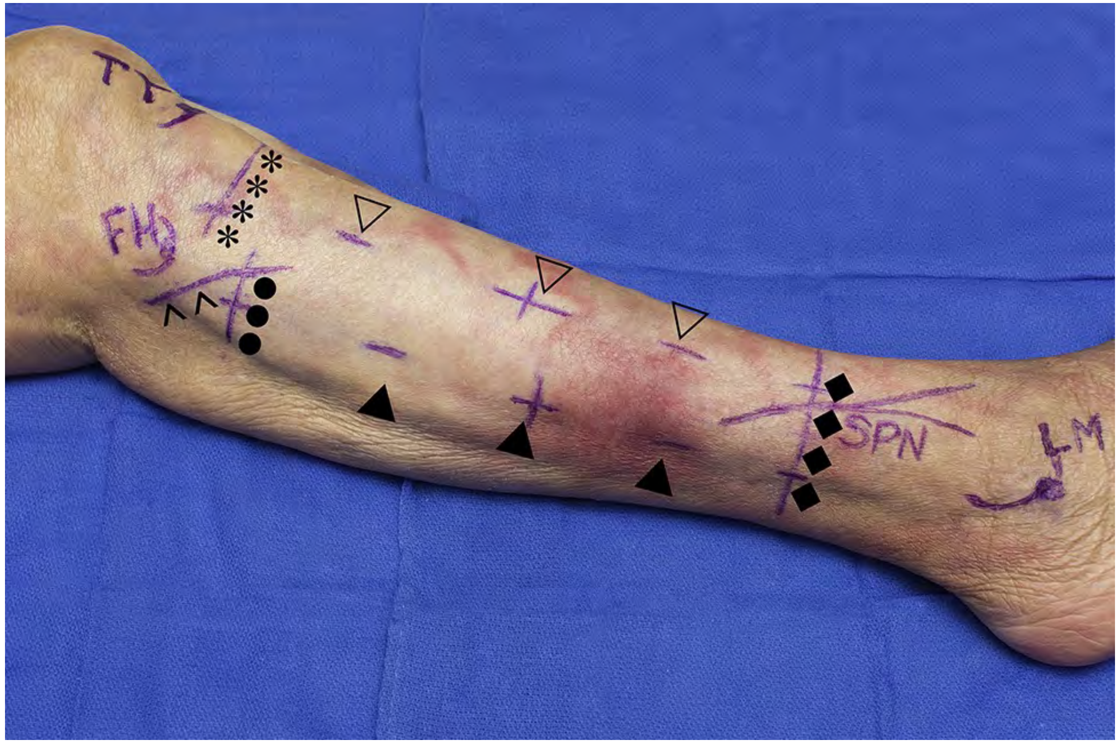
Pre-procedure scan as described for needle fenestration

Compartment borders

- Anterior
  - Proximal: 3 cm distal to tibial tubercle
  - Distal: 10 cm proximal to inferior tip of lateral malleolus
- Lateral
  - Proximal: 3 cm distal to fibular head
  - Distal: same as anterior compartment

Marked meniscotome course on skin

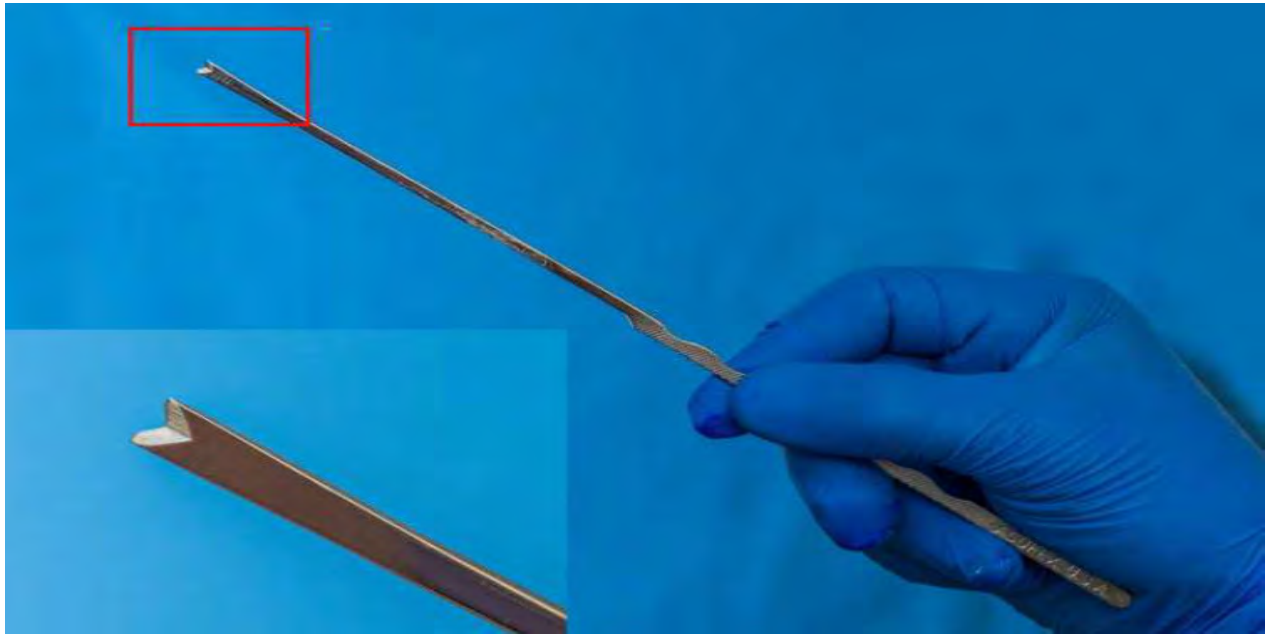
2 meniscotome entry sites per comp



CECS Treatment – US-Guided Fasciotomy

Cutting device

- 3 mm, straight V-meniscotome (Smith and Nephew, Inc., Andover, MA)

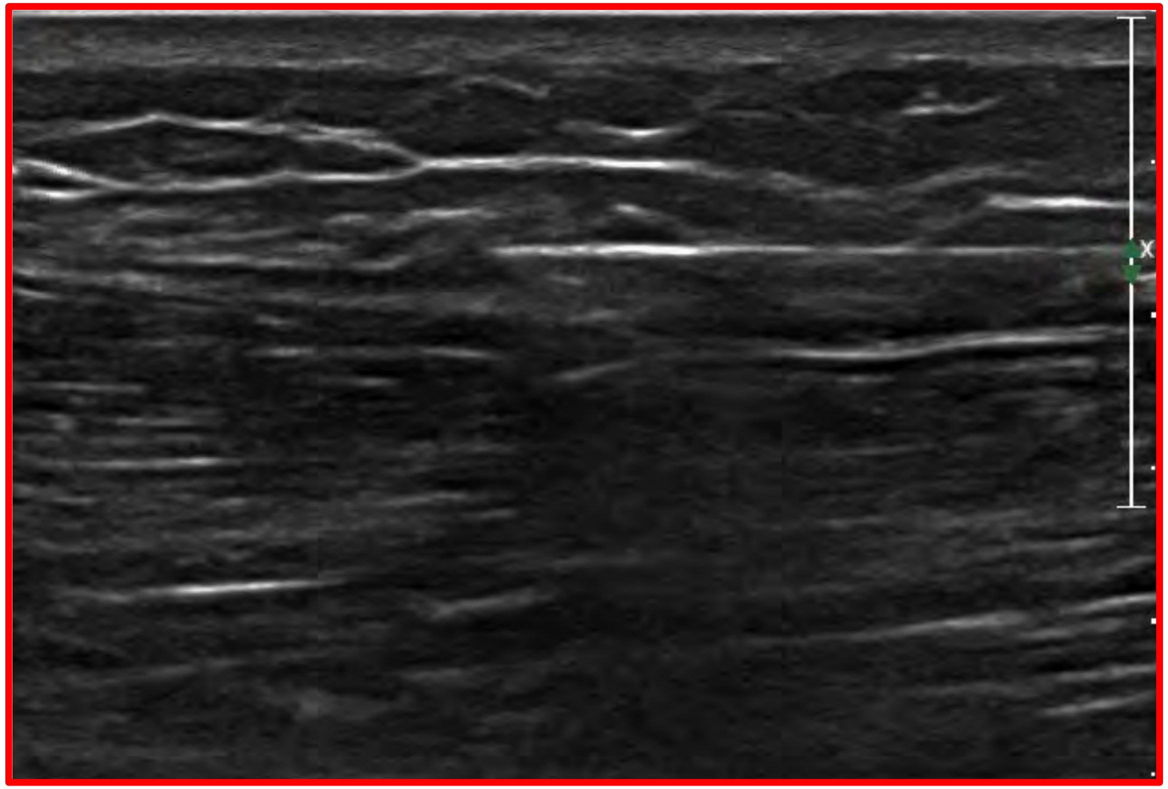


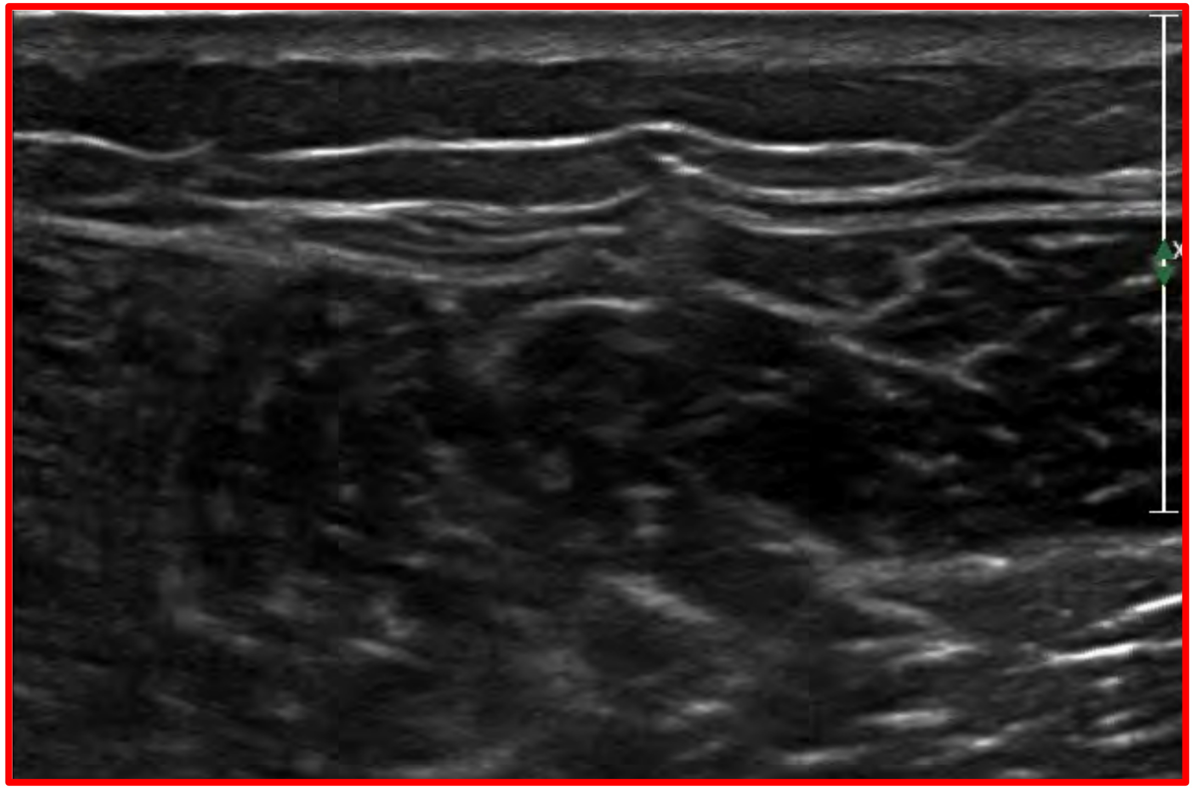
Lueders et al. 2016

CECS Treatment – US-Guided Fasciotomy

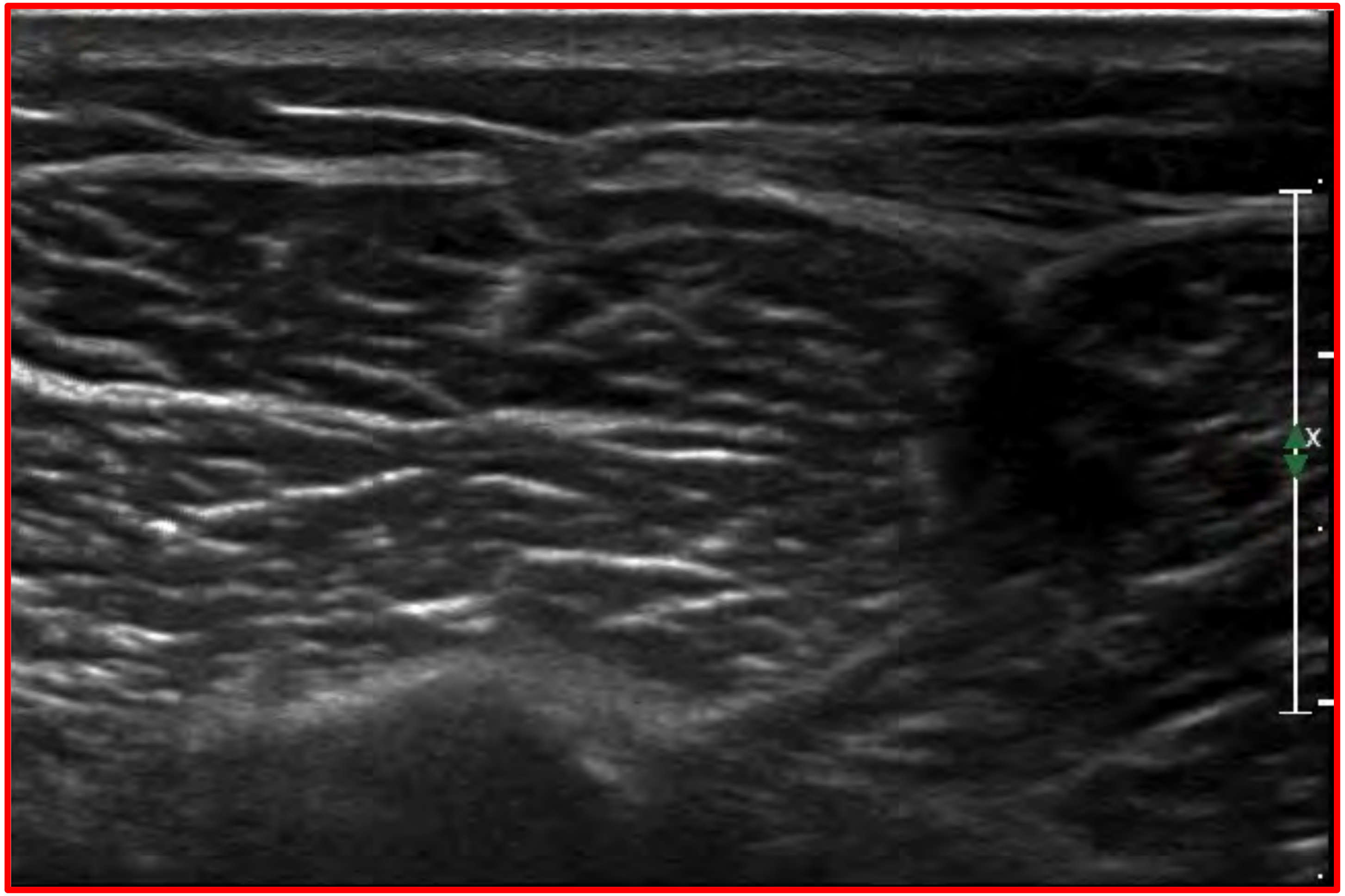
Lueders et al. 2016

CECS - Treatment





CECS - Treatment



CECS Treatment – US-Guided Fasciotomy

Summary

- 1 cadaveric proof of concept study
- 1 case study
- Preliminary safety/efficacy data (unpublished)
- Level 3 evidence
- Appears safe, but further clinical studies are required to determine its efficacy and safety

PAES - Epidemiology

Prevalence

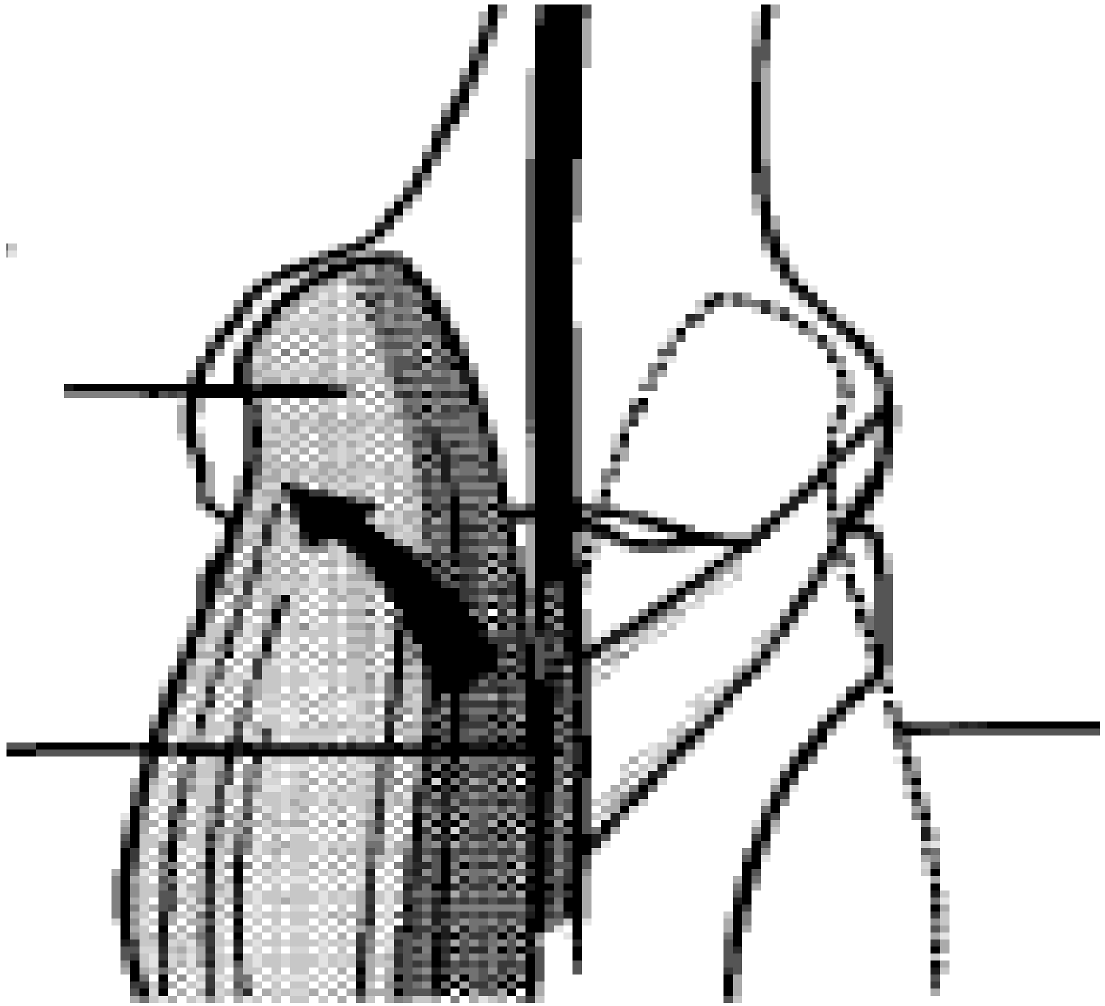
- General population = 3.5%[9]
- Young healthy athletes with claudication symptoms = 60%[10]

1/3 of cases also involve the popliteal vein and may present with signs and symptoms of venous obstruction

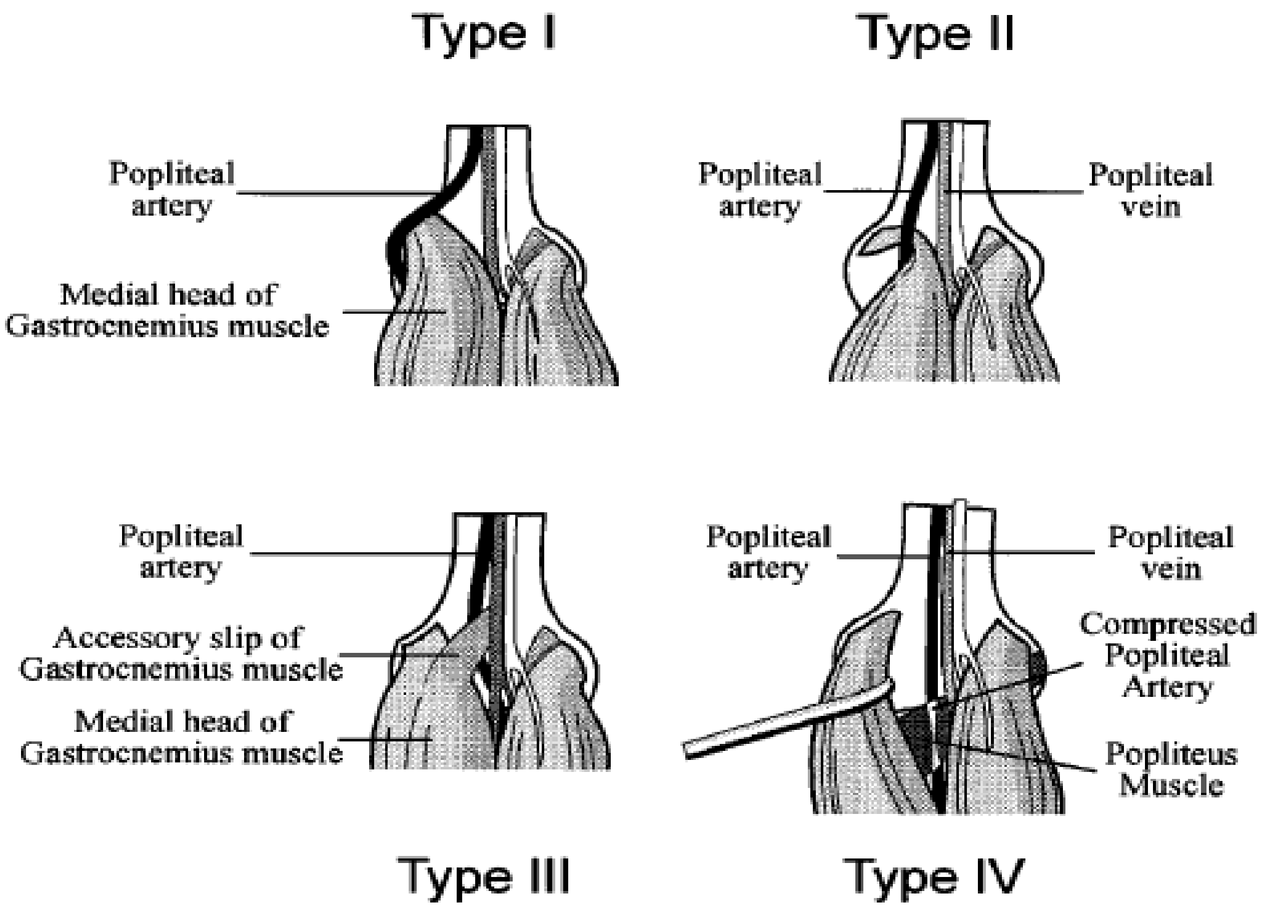
PAES - Etiology

Aberrant relationship between the popliteal artery and adjacent musculature OR can be functional due to compression by medial gastrocnemius muscle with no anatomic abnormalities

PAES – Normal Anatomy



PAES – Classification[12]



PAES - Classification

Type V = Any of the previous types along with popliteal vein entrapment

Type VI = Functional entrapment with normal anatomy

PAES – History and Physical Examination

History

- Leg pain that begins at a specific duration and/or intensity of activity in a young and often athletic individual that is relieved with rest.

Physical Examination

- Passive ankle dorsiflexion or active ankle plantarflexion will cause diminution or absence of posterior tibial and dorsalis pedis artery pulses
- Possible bruit in popliteal fossa

PAES – Diagnostic Studies

Pre- and post-exercise ABI’s

Pre- and post-PAES provocative maneuver ABI’s

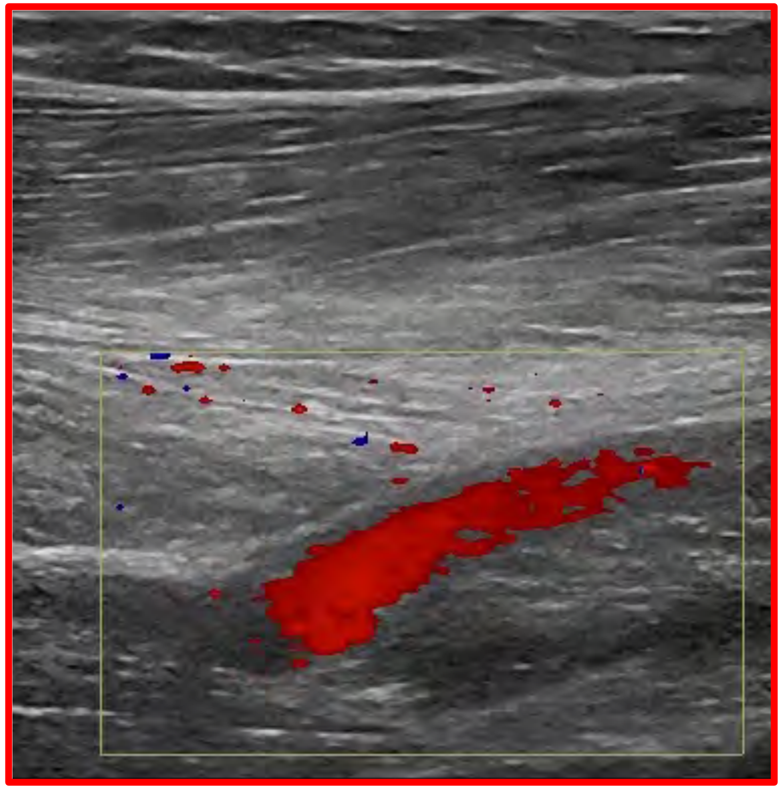
- Post ABI < 0.75 is suggestive of arterial insufficiency
- Post-ABI < 0.66 = 90% sensitive, 87% specific for vascular insufficiency[23]

PAES – Diagnostic Studies

Additional tests with provocative maneuvers:

- Digital subtraction angiography (DSA)
- Doppler ankle pressures
- Pulse volume recordings
- Duplex ultrasound scanning
- CT axial images
- MRI
- MRA

High false positive rate (> 50%) in the asymptomatic population[12]



PAES - Treatment

Types I-V = surgical release

Types VI + classic symptoms = surgical decompression*

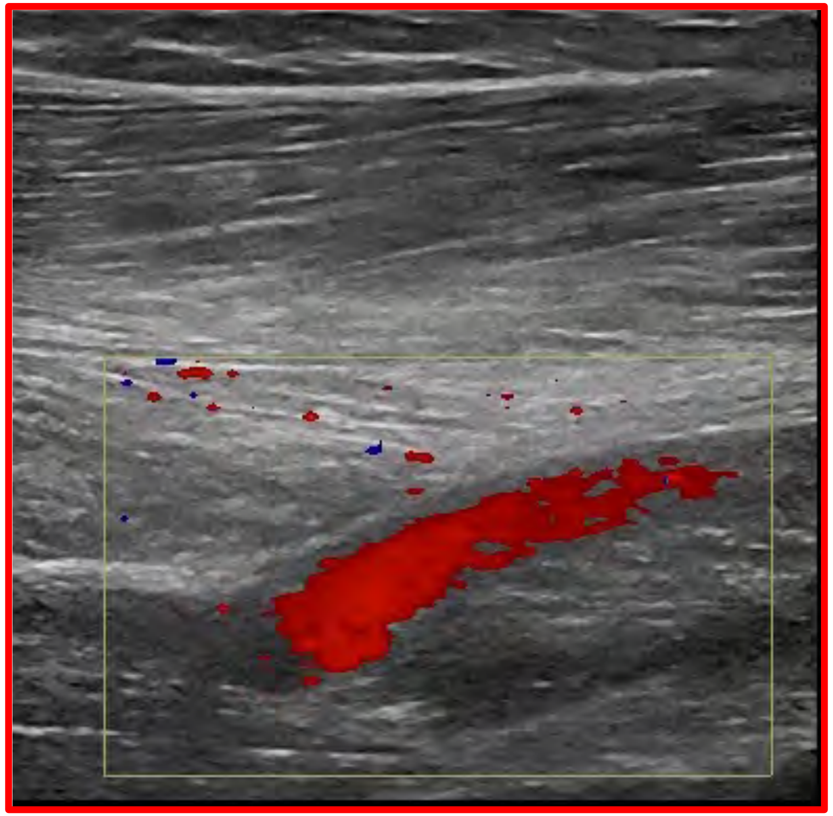
Asymptomatic Type VI = monitor for development of symptoms

If aneurysm or thrombosis has occurred, it should be resected and repaired (e.g.: saphenous vein graft)

Functional PAES (Type VI with classic symptoms) Treatment – Botulinum Toxin A

One Case Report[33]

- 22 y/o French army corporal
- Dx bilateral functional PAES based upon
  - Exertional leg pain symptoms
  - Normal compartment pressure testing
  - Compression of popliteal vasculature with active ankle plantarflexion or passive dorsiflexion while the knee was extended



Functional PAES Treatment – Botulinum Toxin A

Procedure

- Medial and lateral gastrocnemius muscles identified using EMG surface and needle stimulation
- 200 units injected through needle electrode into the proximal third of each muscle, respectively

Post-procedure

- 10 session of gastroc-soleus stretching prescribed

Functional PAES Treatment – Botulinum Toxin A

Outcomes

- 1 month: no pain with fast and prolonged walking
- 2.5 months: normal Doppler sonographic evaluation with dynamic maneuvers
- 4 months: patient able to return to sports, satisfied with treatment
- 1 year: asymptomatic, unrestricted, normal Doppler sonography
- 1.5 years: asymptomatic, unrestricted, normal ABI's
- 3 years: asymptomatic, unrestricted

Functional PAES Treatment – Botulinum Toxin A

Summary

- Interesting, but…
- Only single case study
- Level 5 evidence

CONCLUSION

Conclusion

1. Multiple causes of exertional leg pain
2. Some clues on history and physical examination, but often requires diagnostic tests for definitive diagnosis
3. Several promising, new, minimally invasive procedures for the treatment of exertional leg pain
4. Evidence is very preliminary
5. Further research is required before recommending the wide spread adoption of these techniques

THANK YOU!!

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