Pediatric Acute Compartment Syndrome

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Annual International Orthopaedic Trauma Course

2022

- No disclosures

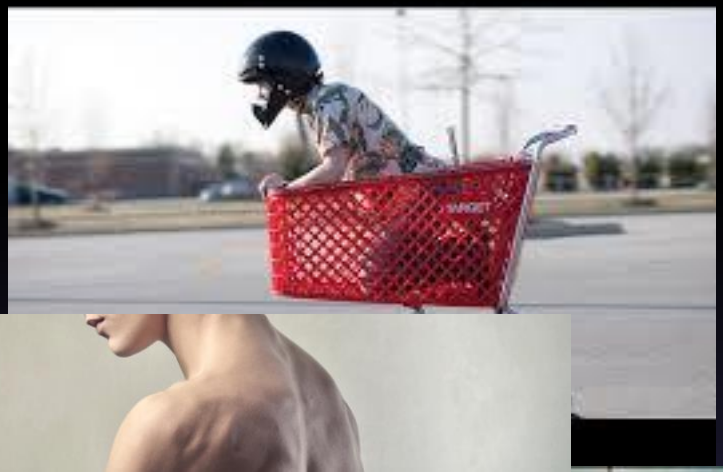
Not just tiny adults!

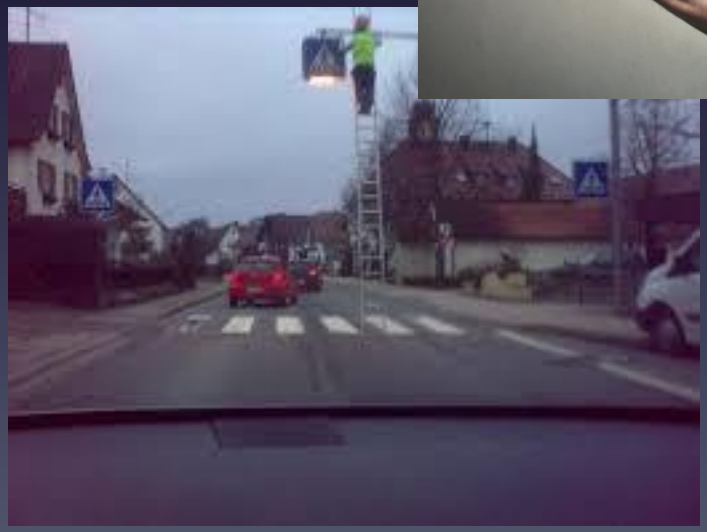
P. A.C.S.

How is P.A.C.S. the same as and different from adult ACS?

- Incidence
- Physiology
- Signs/Symptoms
- Diagnostic methods
- Treatment
- Outcomes

P.A.C.S. Demographics





Who is at risk?

J Bone Joint Surg Br. 2000 Mar;82(2):200-3.

Acute compartment syndrome. Who is at risk?

McQueen MM[1], Gaston P, Court-Brown CM.

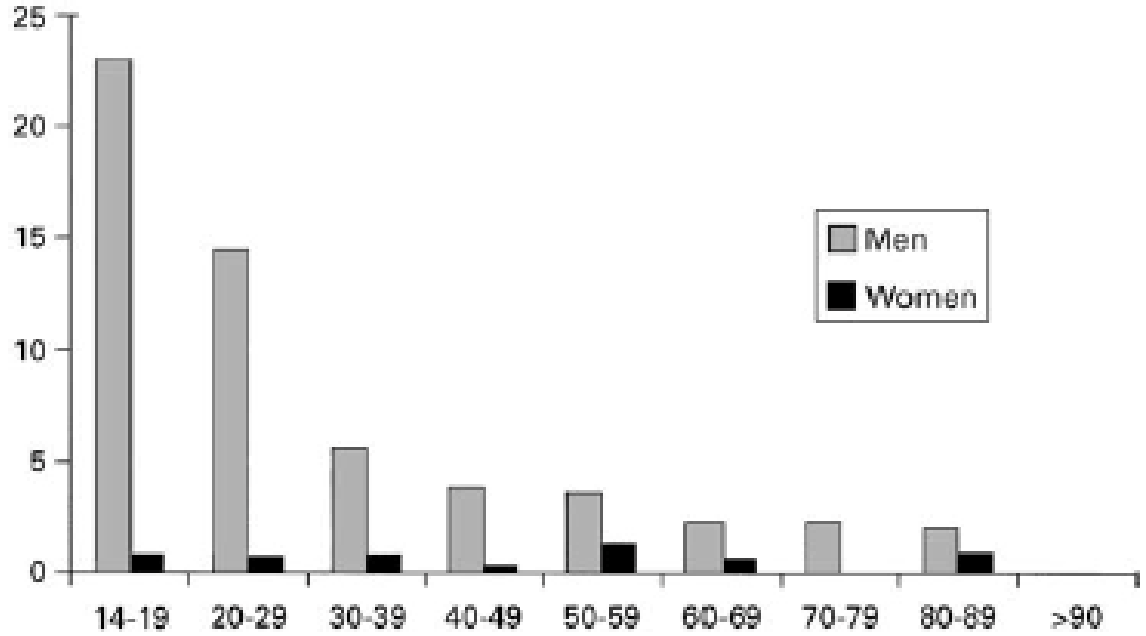


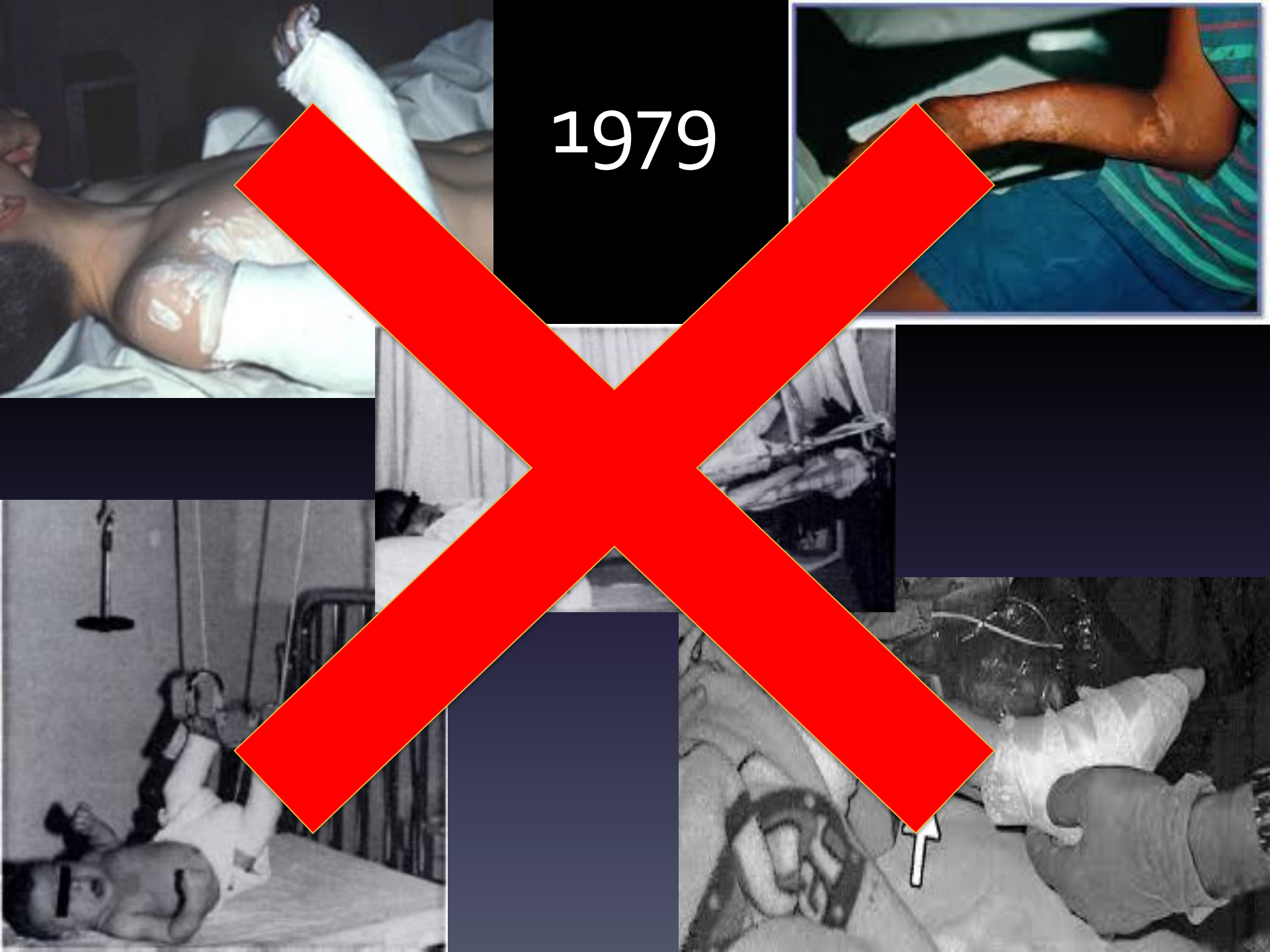
Fig. 1

The average annual age and gender specific incidence per 100 000 of the population for all cases of acute compartment syndrome between 1988 and 1995.

- Age is single strongest predictor of developing compartment syndrome (JOT2015)
- Male gender independent predictor

P.A.C.S. Etiology

- 1) Fracture
- 2) Fracture
- 3) Fracture
  - ~70-80% of P.A.C.S.


1979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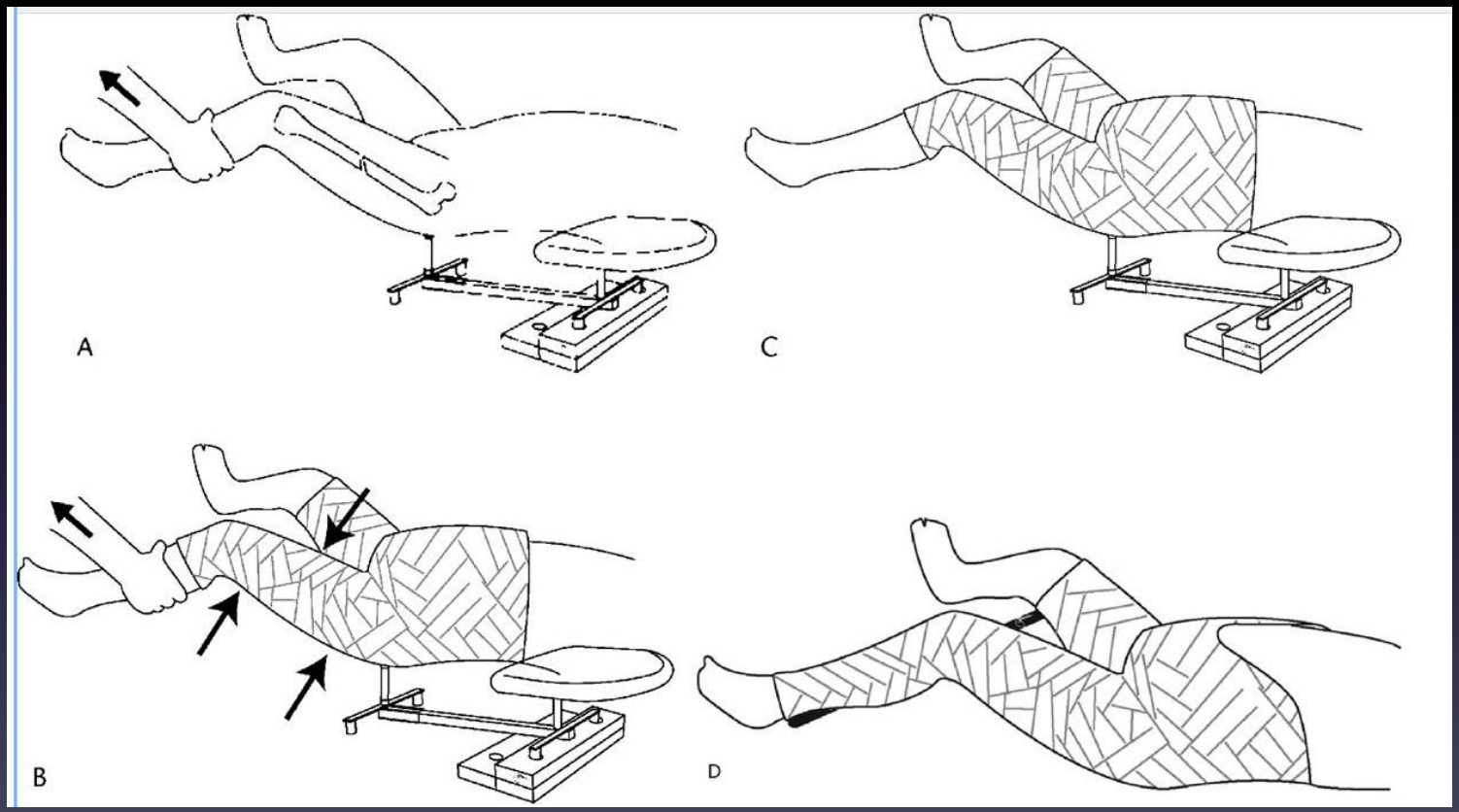
Spica Cast Application



2022

- Bicyclist/pedestrian struck by car
- Tibia fx = 15% of long bone fx in kids, 40% of P.A.C.S.
- 11.5% in children, 20% closed physes, 55% >15, MVC
- UE 51%, LE 49%
- Wrist/forearm fx: 0.7-10% (33% with supracondylar + displaced forearm fx)

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Caution: Floating elbow

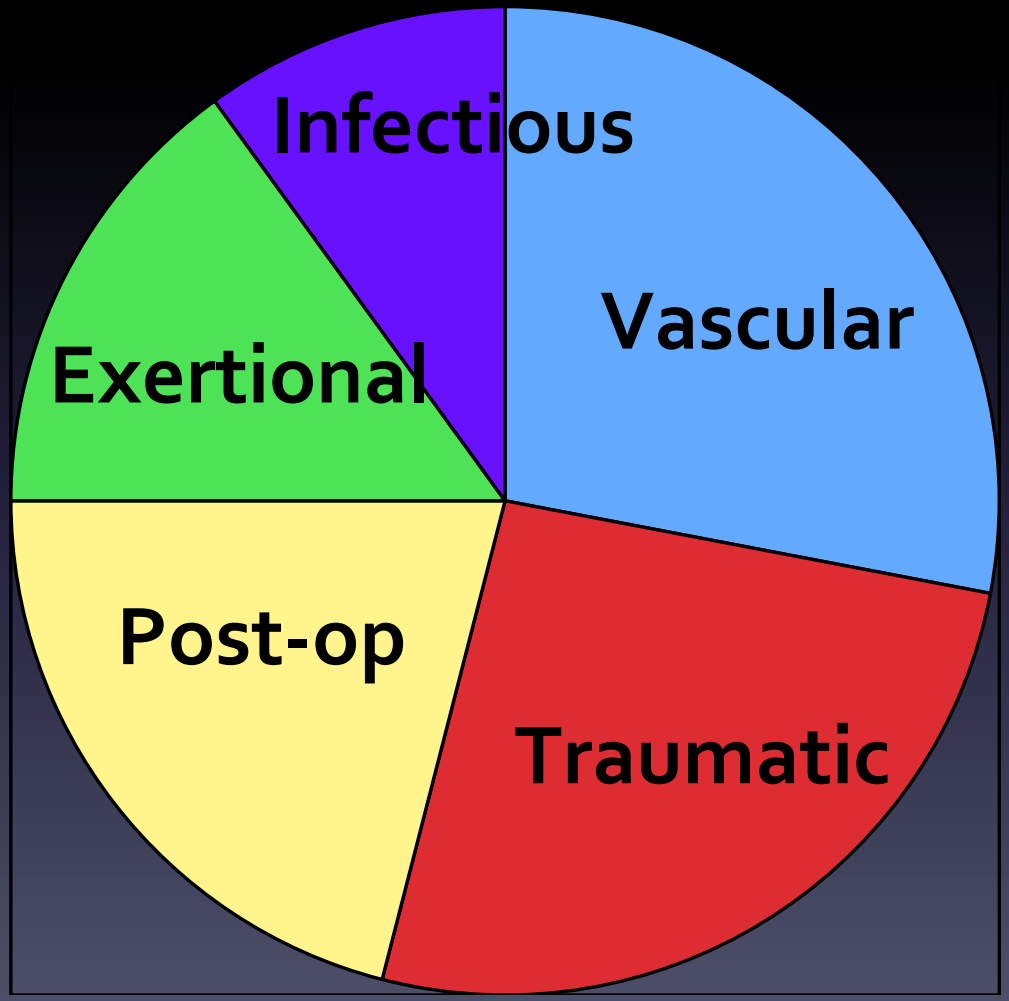
- This is a high energy injury

Upper Extremity P.A.C.S.

- Supracondylar humerus fractures with displaced forearm fracture**
- Forearm fractures (up to 10%)
- Infiltration
- Crush injury
- Tight cast

Non-fracture P.A.C.S.

~20-30% of P.A.C.S.



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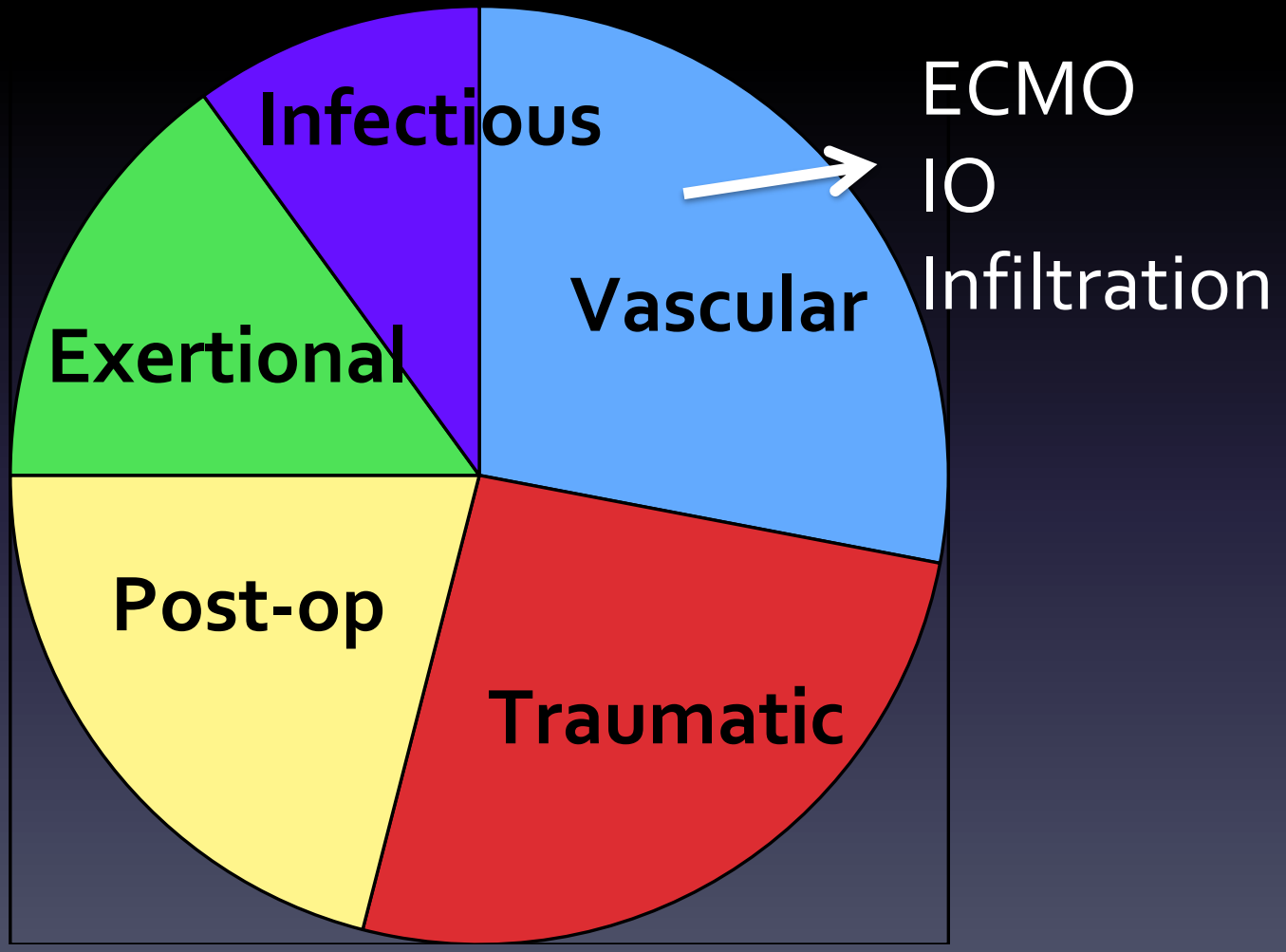
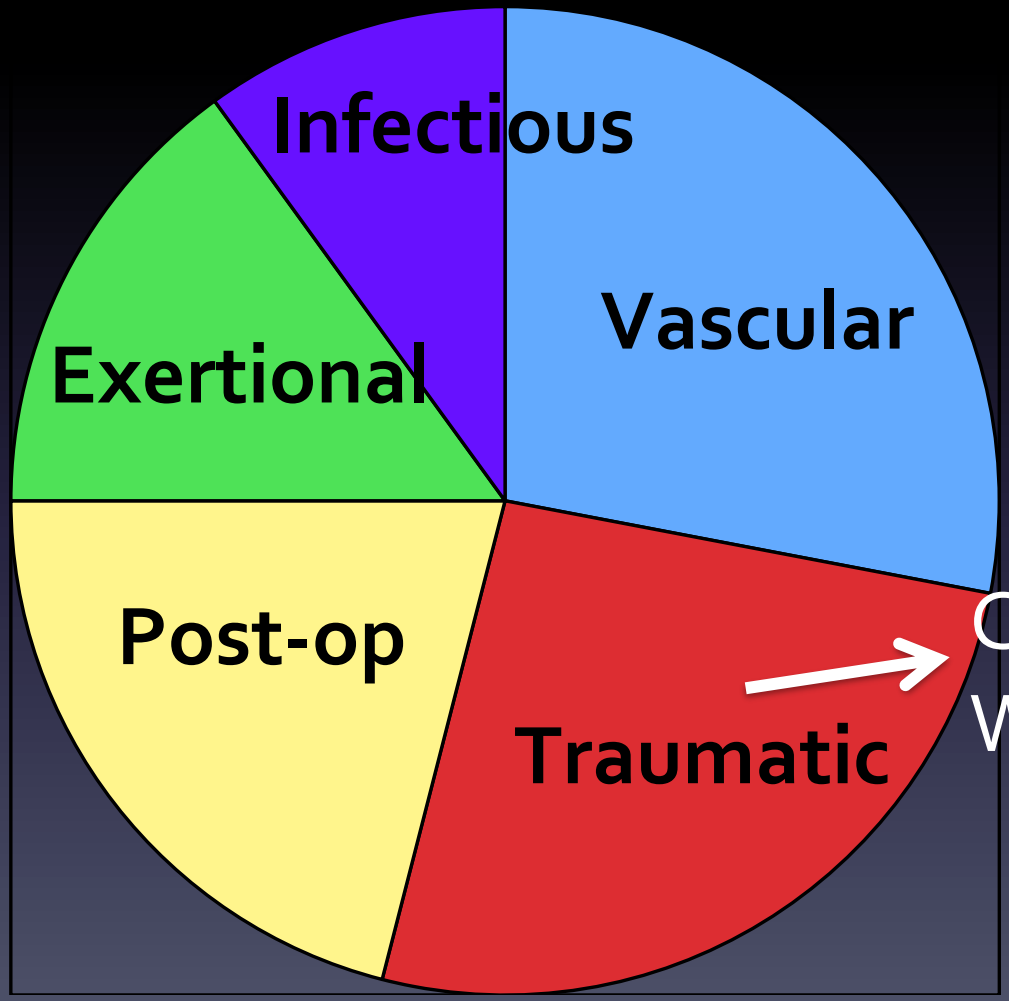


Infiltrations

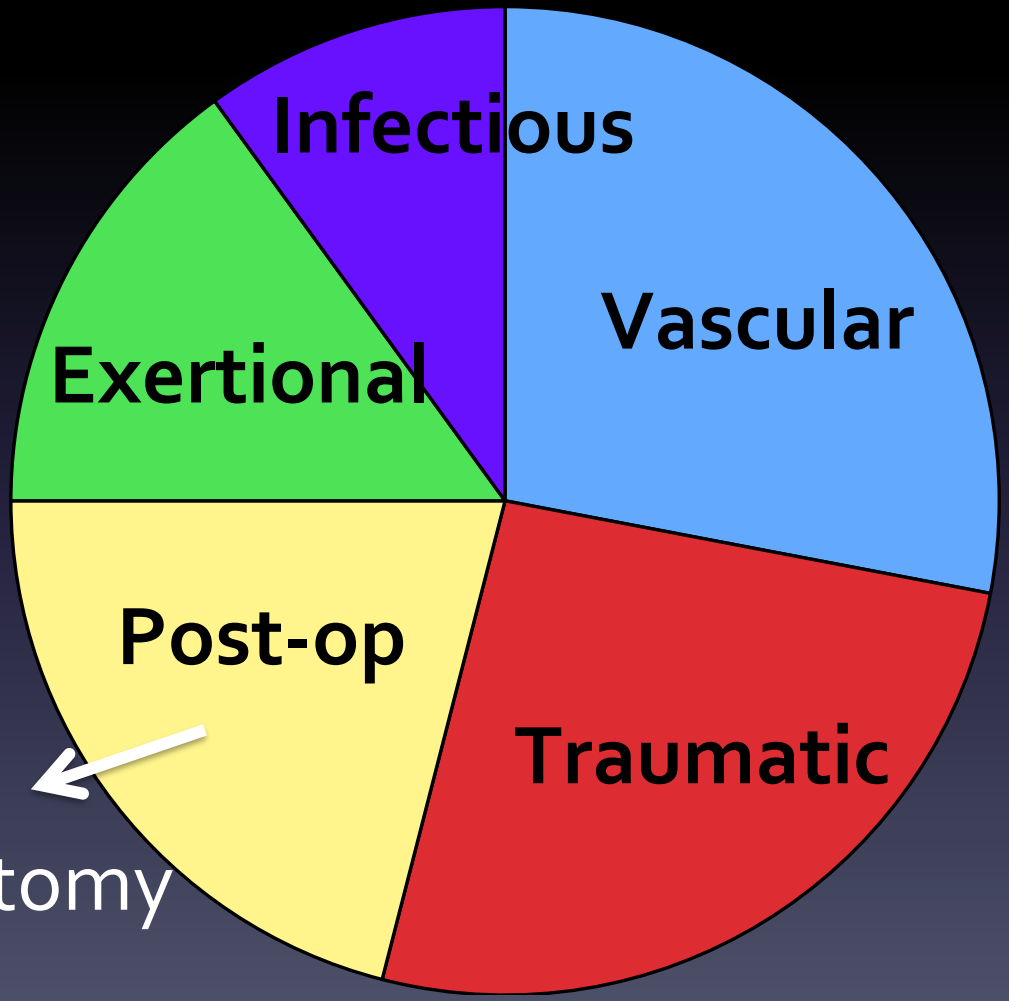
- Kids/infants are particularly susceptible
- Small veins, hard IV's
- Babies can't tell you that an IV hurts
- IO malplacement
- Often recognized late

Non-fracture P.A.C.S.



Crush injury
Wringer injury

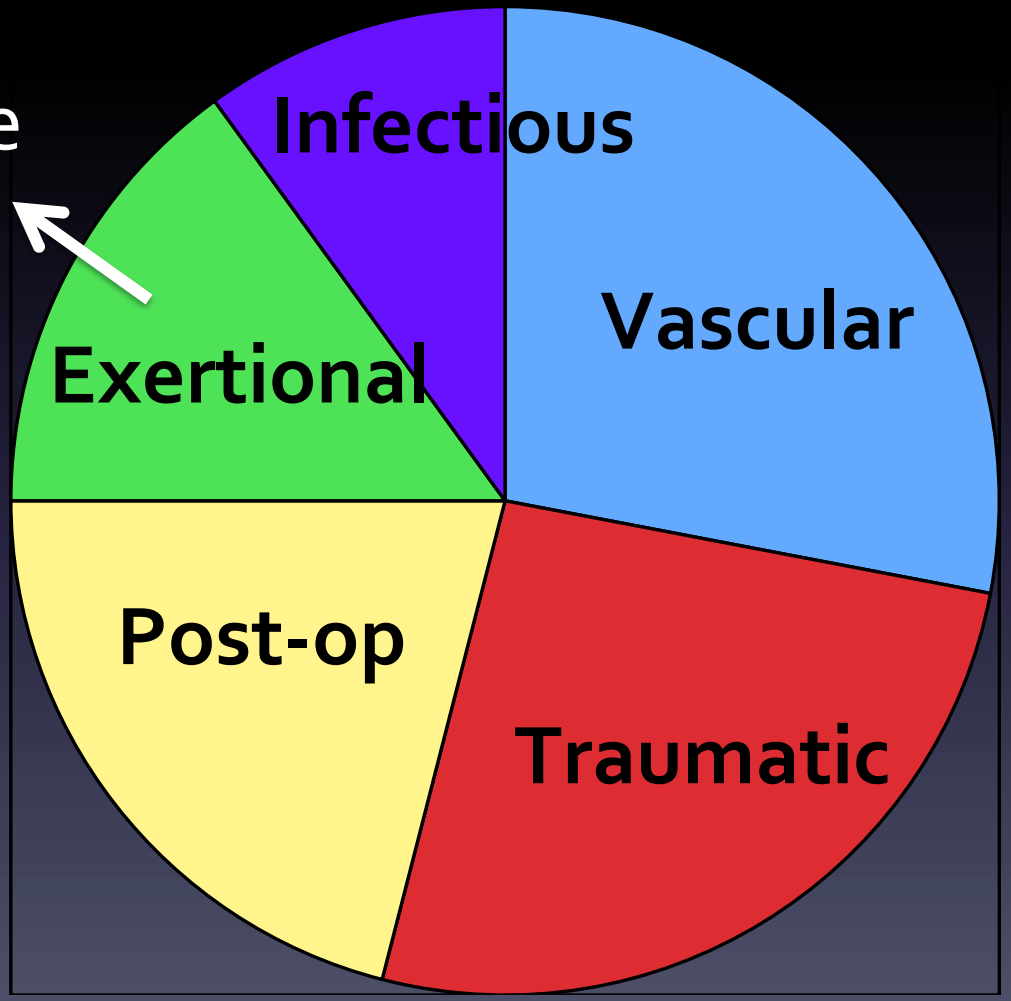
Non-fracture P.A.C.S.



Osteotomy
Dorsal lithotomy

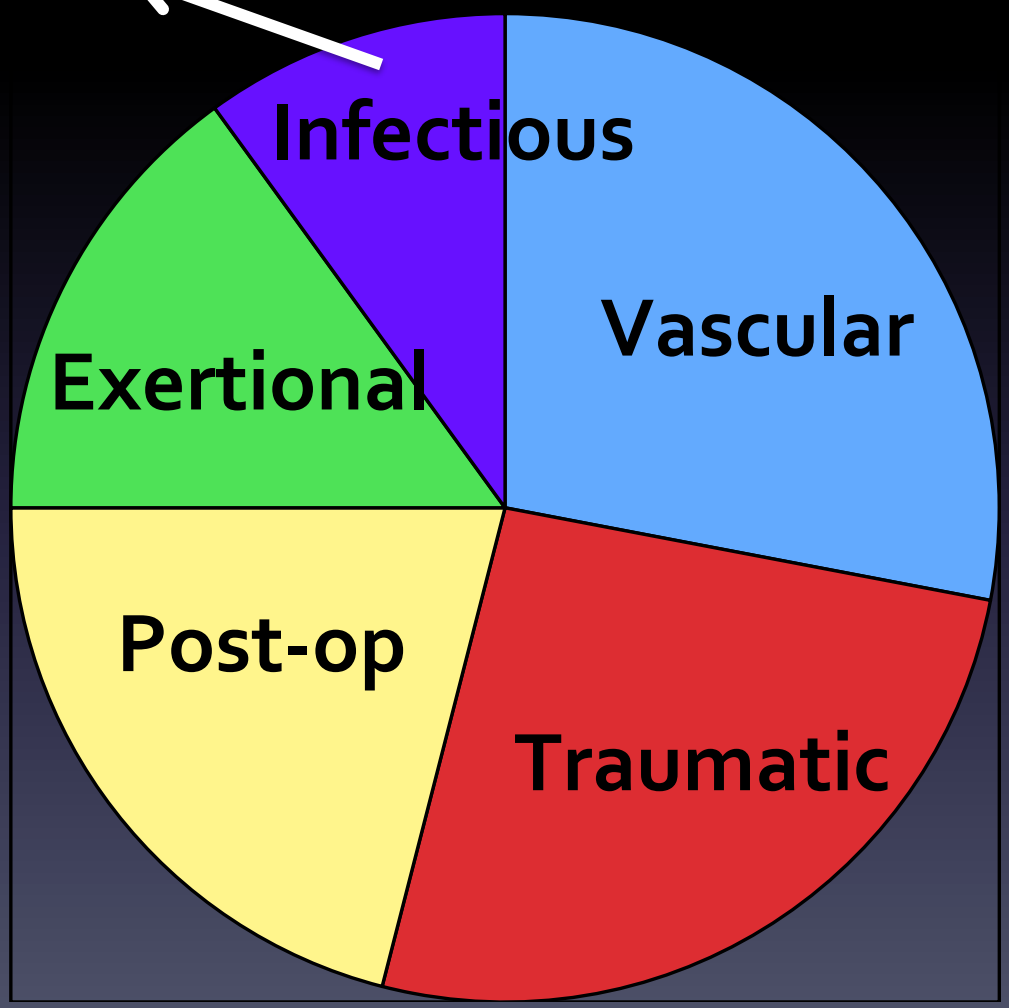
Non-fracture P.A.C.S.

~17 yo male athlete

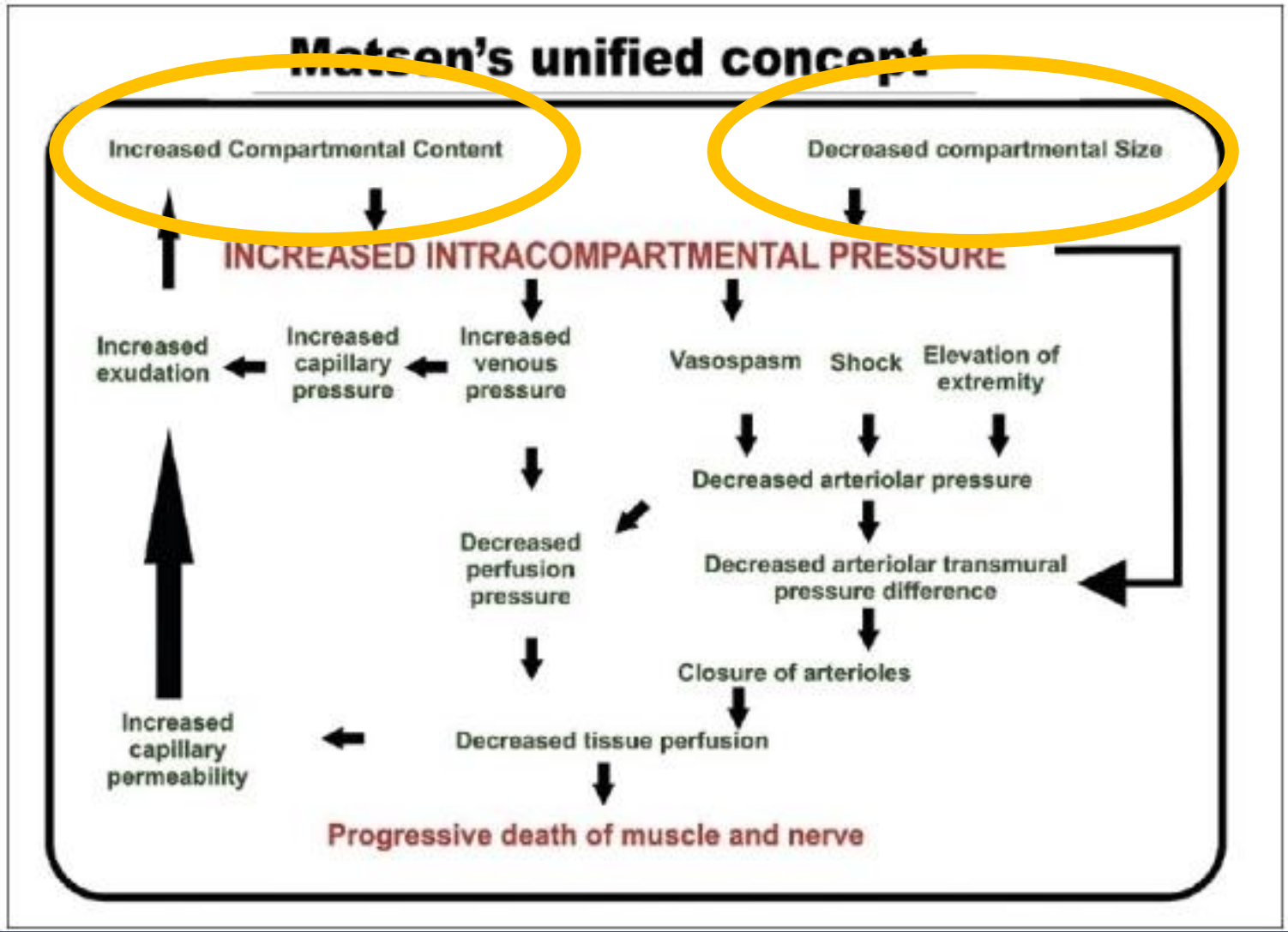


Non-fracture P.A.C.S.

Pyomyositis



P.A.C.S. Physiology



ACS "Dog"ma

- Where physiology may differ: time course
- Whitesides 1970's
  - Tourniquet on hind limbs of dogs for 4-10 hours.
  - 4 hours tourniquet time: <5% of muscle cells damaged
  - 8 hours tourniquet time: 100% irreversible muscle cell injury in 10/14 cases
- Based on adult dog physiology and tourniquets
  - How much can we rely on this? In children?

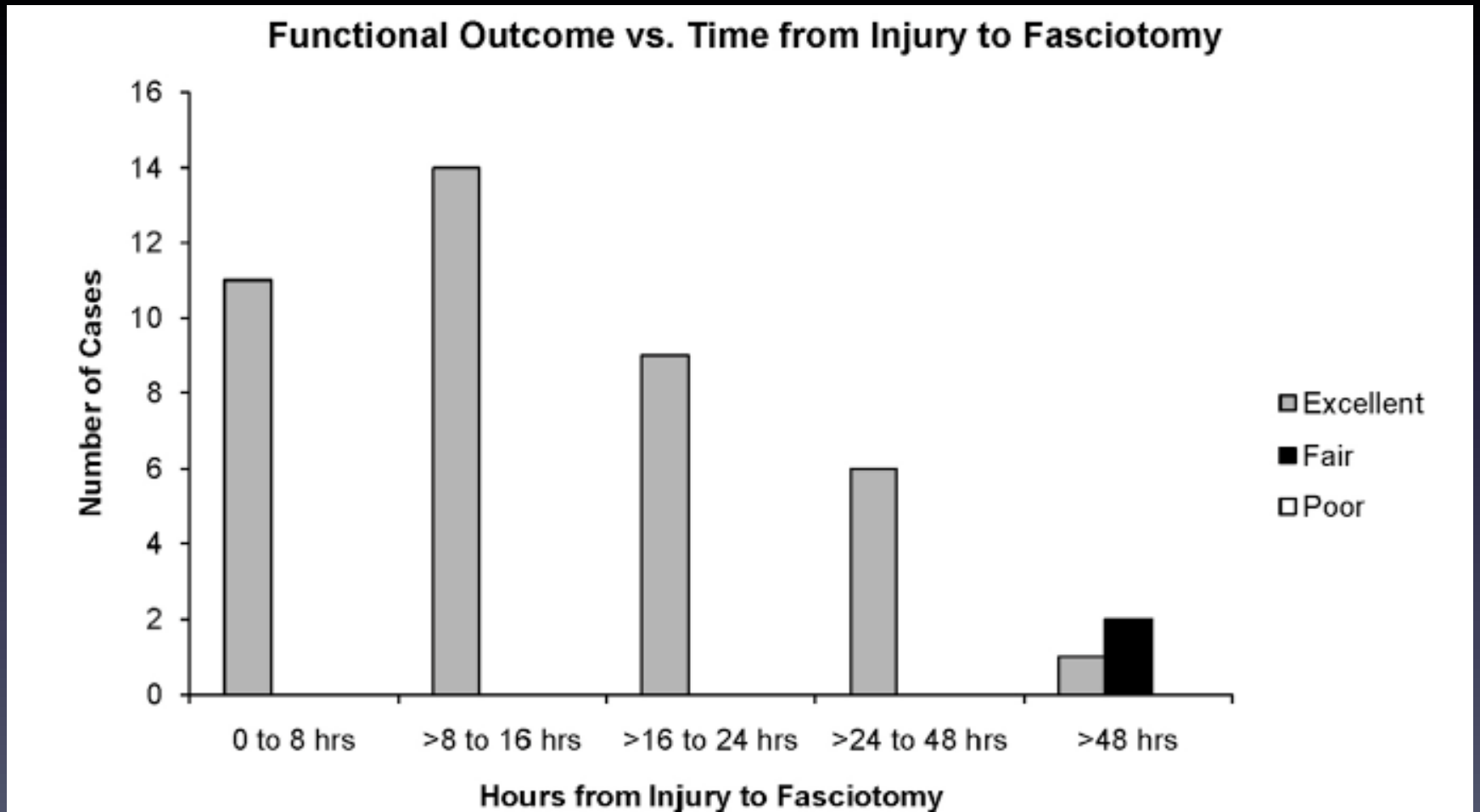
P.A.C.S. Physiology

- Time course of 4-8 hours: too simple?
- Maybe longer in children
  - Most P.A.C.S. series have delay in diagnosis but excellent outcomes
  - Mean time from injury to fasciotomy ~25 hours
  - 80-95% complete recovery
  - Kids are much more resilient

Acute Traumatic Compartment Syndrome of the Leg in Children: Diagnosis and Outcome

By John M. Flynn, MD, Ravi K. Bashyal, MD, Meira Yeger-McKeever, MD, Matthew R. Garner, MD, Franck Launay, MD, and Paul D. Sponseller, MD, MBA

Investigation performed at the Children's Hospital of Philadelphia, Philadelphia, Pennsylvania, and the Johns Hopkins Hospital, Baltimore, Maryland



Time is tissue! But…

- Kids have longer time to fasciotomy but better results
- Why the longer time to diagnosis: hard to diagnose? Or take longer to develop peak pressures? Or both?
- Physiologic reserve
- Kids tolerate higher pressures better
- Kids may have a longer and more benign disease course than adults

Why does it take so long to diagnose P.A.C.S.?

It's hard to examine kids

- Swelling is very difficult to assess in small child (especially baby) – soft tissue envelope vs muscle compartment
- Comprehension of exam
  - "Does this feel normal???" Do they know what "numb" means?
  - 2 Point discrimination may be more objective
- Cooperation/attention
- Pain scale – objective >> subjective
  - Pain medication usage, serial pain scores

Beware the 5 P's

- Specificity high, Sensitivity low
- High probability with **≥3** findings (5 P's)
- Pain with passive stretch, out of proportion and loss of 2-point discrimination
- Pain may be unimpressive or difficult to interpret
- Pain may not register with underlying neuroapraxia
  - E.g. Supracondylar with median nerve deficit

P.A.C.S. Diagnosis

- 3 A's
- Increasing Analgesia, Agitation, Anxiety
- Increasing analgesia dosing = ***7.3 hours*** earlier than uncontrolled pain or neurovascular changes
- My rule: SOMETHING SEEMS WRONG

Bae et al. JPO 2001

P.A.C.S. Diagnosis

- Clinical diagnosis!
- Pressures only when needed. ICP may be impossible to obtain bedside in scared, agitated uncooperative, preverbal child or even a teenager
- Pressures in OR as adjunct – but your clinical exam is most important

Normal pressures

- Babies: ????? Not useful
- Children: **13.3-16.6mmHg** at rest
- Adults: **5.2-9.7mmHg** at rest
- Threshhold?
  - P>30? ΔP<20 from diastolic? ΔP <30 from diastolic?
- Children may tolerate >30-40mmHg as long as delta P>30 from ***MAP***

Mars, Hadley. Raised intracompartmental pressure in children: a basis for management. *Injury*. 1998

P.A.C.S. Treatment

- Emergent fasciotomy.

Is there such a thing as non-operative treatment?

Fasciotomy in the Treatment of the Acute Compartment Syndrome*

BY [illegible]REY W. SHERIDAN, M.D.†, AND FREDERICK A. MATSEN III, M.D.†, SEATTLE, WASHINGTON

- Infection rate 46% and amp rate 21% after late fasciotomy (>12 hours) (8% normal function)
- 5% and 0% after early fasciotomy (68% normal function)

Lower Limb Compartment Syndrome: Course after Delayed Fasciotomy

Finkelstein, Joel A. MD, FRCS(C); Hunter, Gordon A. MB, FRCS, FRCS(C); Hu, Richard W. MD, FRCS(C)

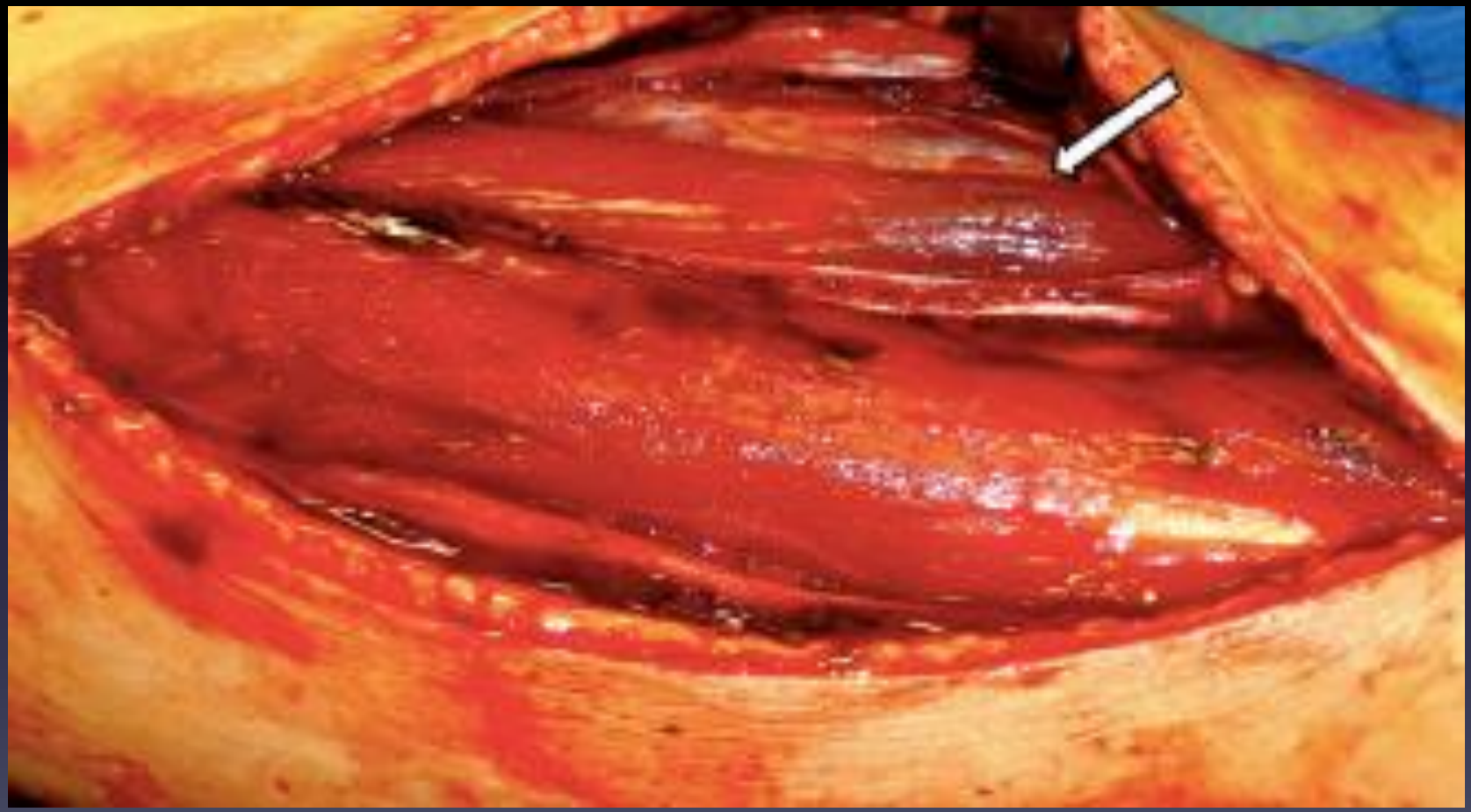
- In adults, advocate to avoid late fasciotomy after 8-10hrs of established compartment syndrome to avoid infection and plan for late reconstructive procedures

Is there such a thing as non-operative treatment in kids?

NO!

- IT'S NOT TOO LATE IN KIDS
- Low risk of infection (rarely reported)
- Multiple reports of ischemic → healthy muscle in kids
- Recovery may be robust – especially in infants/toddlers

LIGHT Debridement



To graft or not to graft?

- Children: Only 12-21% require complex closure
- Many closed after second washout
- Consider single lateral incision

KEEP TRYING

P.A.C.S. Outcomes

- Why we like treating kids:
  - 80-95% complete recovery

Lessons

- Beware the 17 year old boy with tibia fracture after MVA
- Time to P.A.C.S. is still 

- 3 A's
- Always operate – even if it's late!
- Debride LIGHTLY in kids
- Can often close after multiple washouts

Thank you!

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