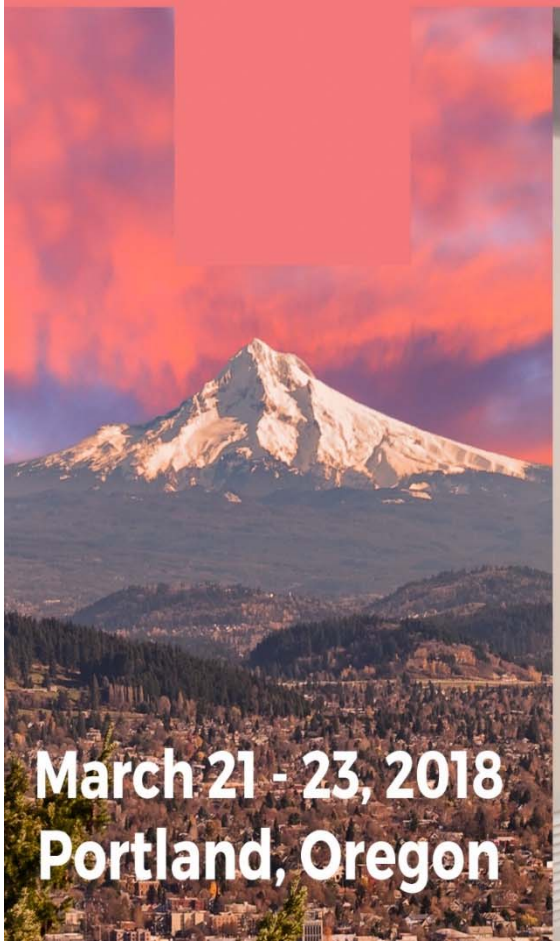
SOCIETY OF TRAUMA NURSES

TRAUMACON



The Not So Secret Compartments

Jane E McCormack, RN, BSN, TCRN
Trauma Program Manager
Stony Brook University Hospital

Disclosure Statement

- Faculty/Presenters/Authors/Content Reviewers/Planners disclose no conflict of interest relative to this educational activity.

Successful Completion

- To successfully complete this course, participants must attend the entire event and complete/submit the evaluation at the end of the session.
- Society of Trauma Nurses is accredited as a provider of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

Objectives

1) Define CS and understand it as a 'time sensitive' event
2) Identify risk factors, injury factors, and treatment factors that increase risk
3) Use case scenarios to identify risk, recognize S/S, early treatment of and long term patient needs

"Typical" case presentation
"Atypical" case presentation
Programmatic considerations
Nursing focus

Stony Brook University Hospital

ACS Level I Adult and Level I Pediatric Trauma Center

603 bed Academic Medical Center

50 miles east of New York City

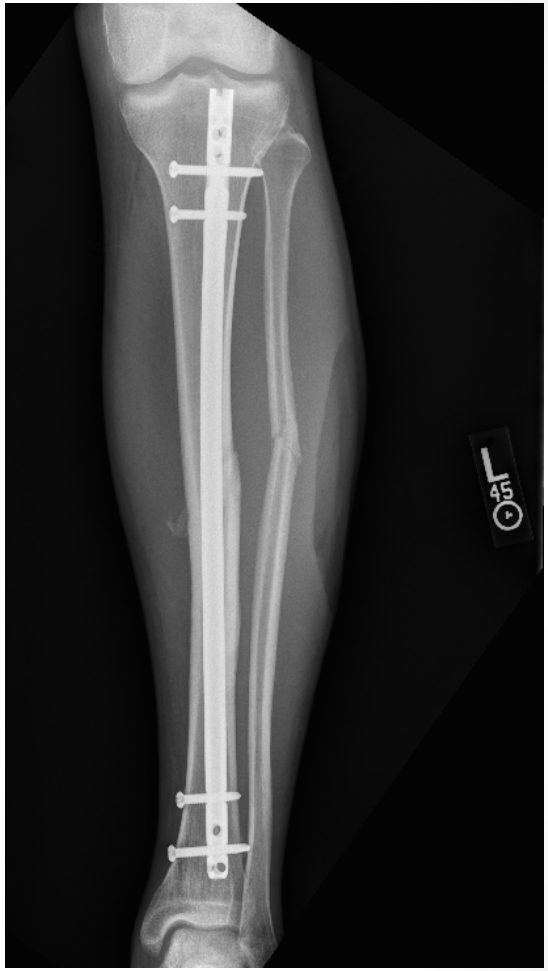
Serve a suburban and rural population of 1.5 million

Case #1

- 23 year old soccer player jumped and landed on his extended left leg
- Acute, angulated fibular and tibial midshaft fracture
- Bi-valved cast placed
- IMN performed next morning

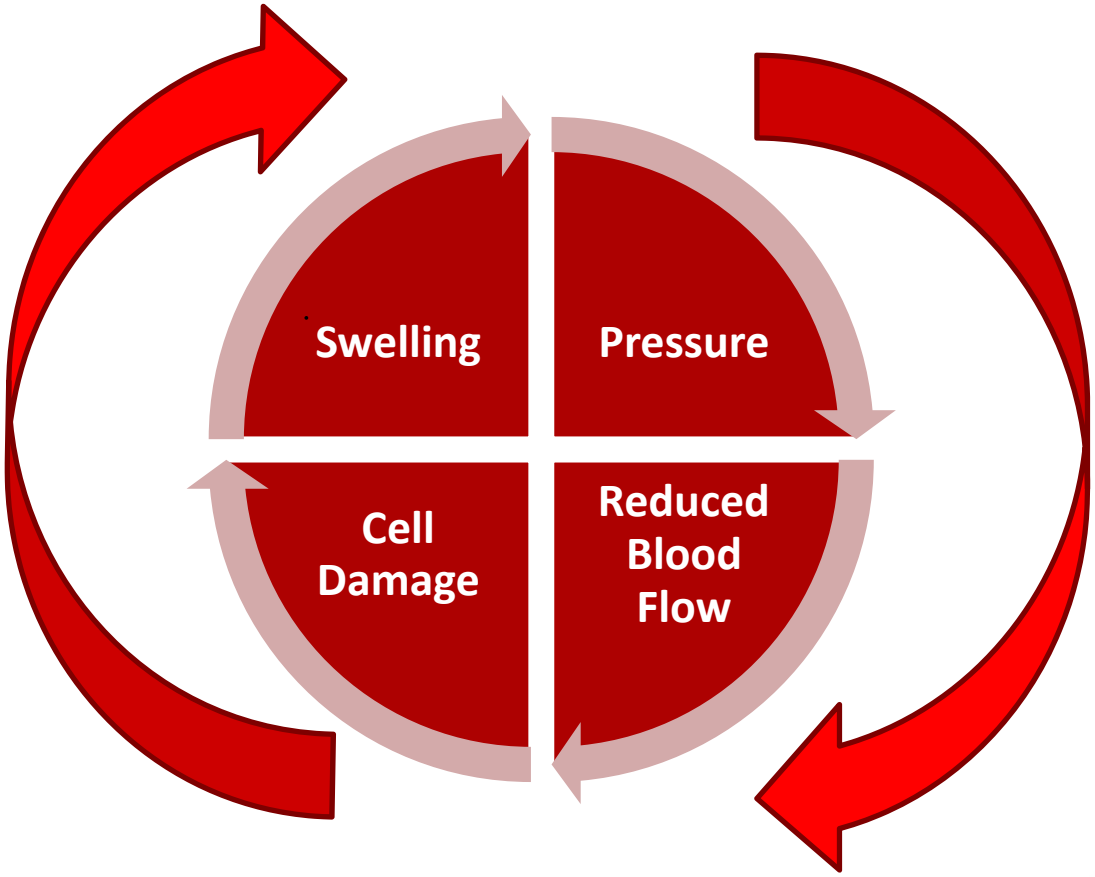
Post Op Course

Day	Events
POD 1	LLE compartments soft
Overnight	Pain rating 6-8 out of 10 3 doses of narcotics
POD 2	Anterior compartment more swollen and less compressible. Frank pain with passive flexion of toes. Discomfort with toe dorsiflexion



Acute Compartment Syndrome

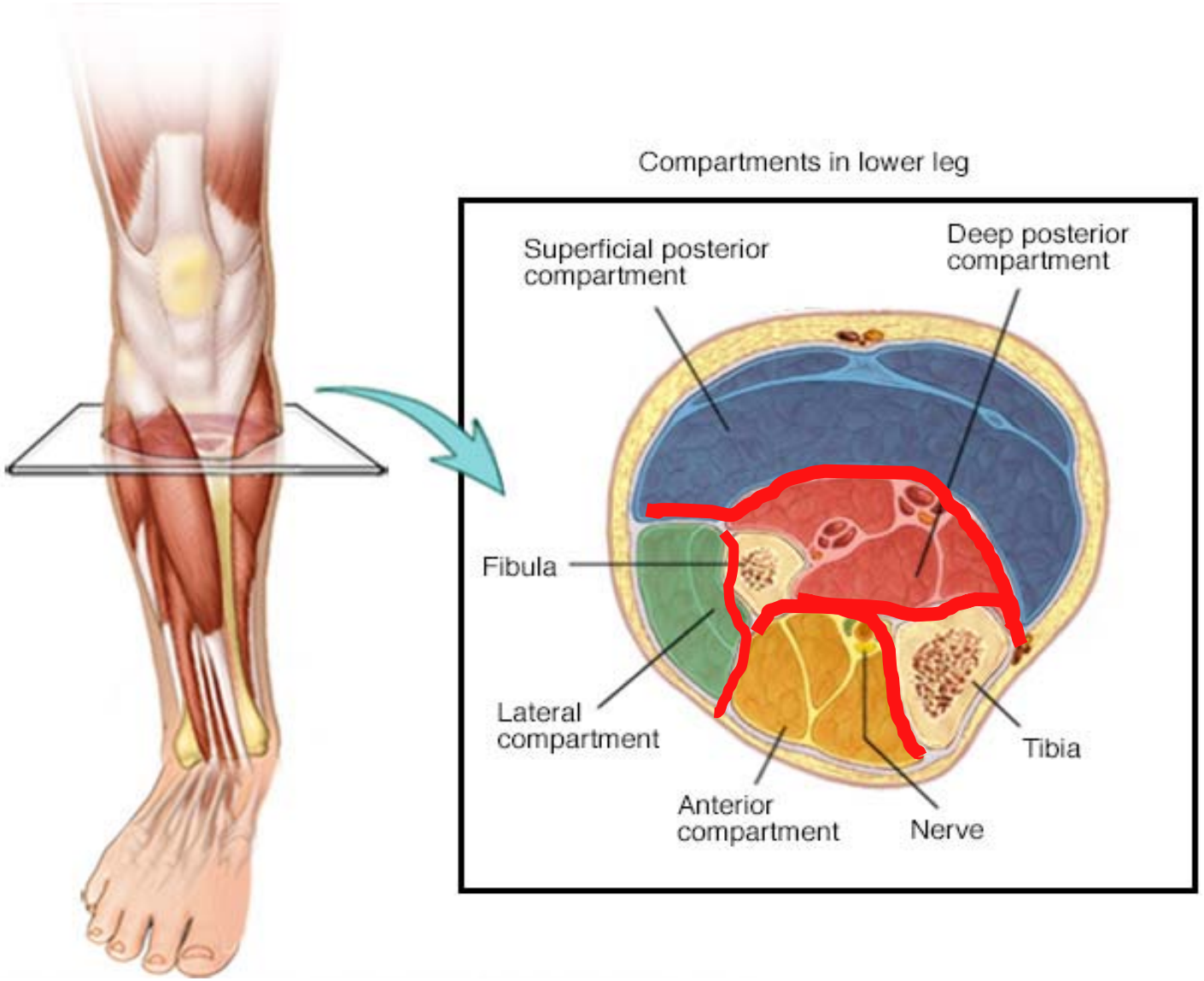
- Increased pressure within a muscular compartment that impairs circulation
  - Untreated → ischemia → infarction →contracture



Fascia

- Fibrous net
  - Organizes and separates muscle
  - Does NOT stretch
- 46 facial compartments
  - Contain muscle, nerve, blood vessels
  - 38 in extremities, 8 in trunk

Lower Leg Compartments



Mass Exceeds Space

- Inelastic fascia defines space size
- Swelling, bleeding, inflammation increases size

Causative Event

- External
- Internal
- Exertional
  - Chronic compartment syndrome in athletes
  - Not part of today's discussion

Cause

- **External** (reduced compartment size)
  - Compression
    - Cast, splint
  - Restricted flow due to positioning
    - Unconscious person, IVDA
    - Anesthesia

Oregon
Montana
North Dakota
Minnesota
Maine
New Hampshire
Idaho
South Dakota
Wisconsin
Michigan
New York
Rhode Island
Connecticut
New Jersey
Wyoming
Iowa
Pennsylvania
Nevada
Utah
Nebraska
California
Illinois
Ohio
West Virginia
Delaware
Maryland
Colorado
Indiana
Kansas
Kentucky
Virginia
Missouri
North Carolina
Tennessee
Arizona
New Mexico
Oklahoma
Arkansas
South Carolina
Georgia
Mississippi
Alabama
Texas
Florida
Louisiana
Hawaii
Alaska

DUTY
FREE
ANASTASIA BELTYUKOVA/CNN

Cause

- External (reduced compartment size)

- **Internal** (increased compartment content)
  - Swelling
  - Fractures
  - Crush injury
  - Snake bite
  - IV infiltration/extravasation

Is our soccer player 'typical'?

- Male
  - Overwhelming occurs in males
- Young
  - 3x higher rate in < 35 year old
- Fracture
  - 75% of cases are associated with fracture
    - Not more likely with closed (vs. open) fracture
  - Tibia is most common location (36%)
    - Middle and proximal fractures have higher incidence (Beebe, 2017)
- Clinical presentation
  - Within hours of injury, but can present 48-96 hours later
    - Associated with posterior tibial nailing

Taylor, Sullivan, Mehta, 2013
Donaldson, Heddah, Khan 2014
Thabert et al 2017

Problematic Diagnosis

- Clinical diagnosis
  - Confirmed by measurement of intra-compartmental pressure
  - Time Sensitive
    - Delay in diagnosis and treatment causes muscle loss
- Definitions vary in research studies

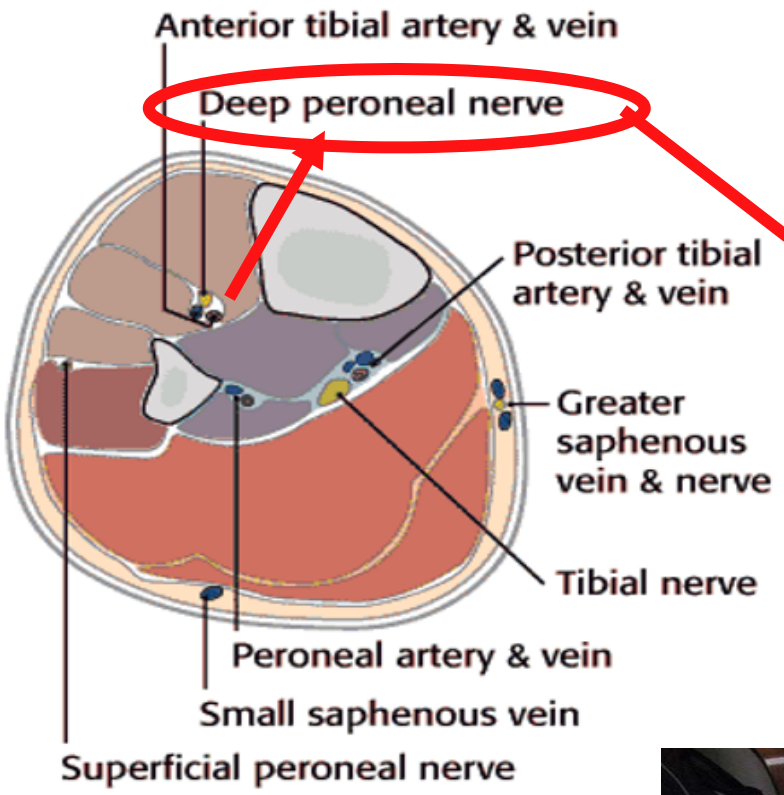
The Clinical **P**'s

- **P**allor, **P**ulselessness, **P**alpable tenseness, **P**aresthesia, **P**ain

- Not reliable
  - Microvascular system disorder
  - Late signs/symptoms

- Subjective
  - posterior compartment tenseness → least likely affected

Paresthesia



PAIN

- Most common and consistent sign
- Out of proportion with expected clinical course
- With passive stretching

- Complicated in ‘complicated’ patients
  - Regional or spinal anesthesia
  - Unresponsive
  - Unreliable
  - Multi-trauma

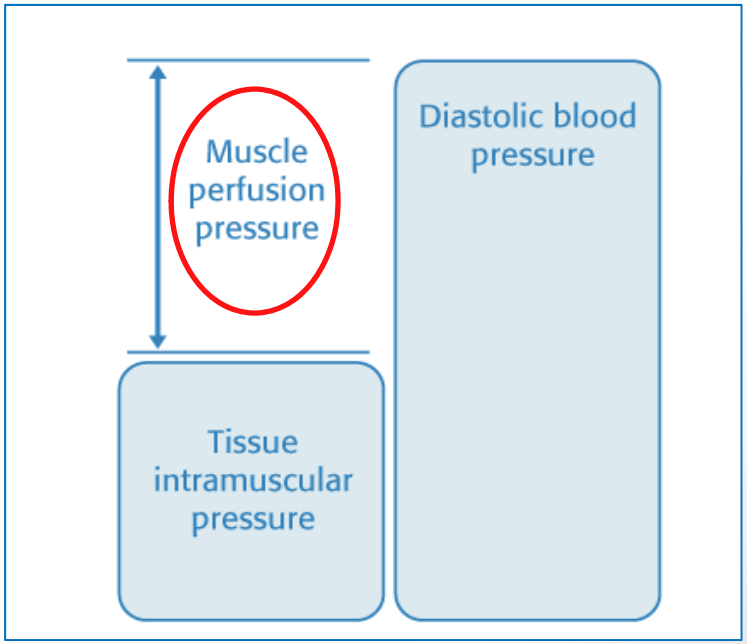
A's in Pediatrics

- Increasing Agitation, Anxiety, Analgesic needs *(Noonan & McCarthy, 2010)*

- *Increasing analgesic requirements preceded the change in vascular status by an average of 7 hours. (Livingston, 2016)*

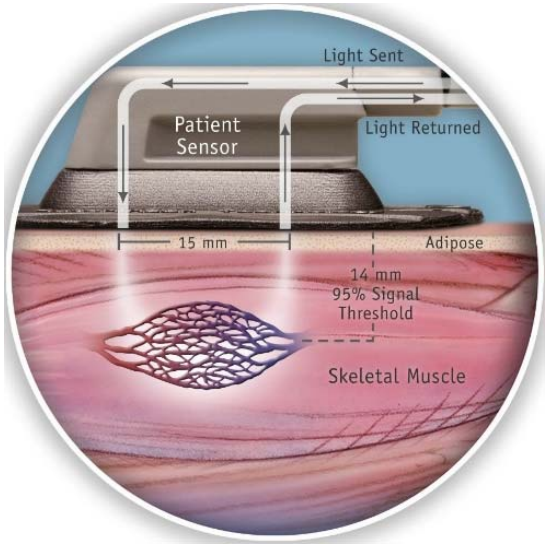
Pressure Measurement

- Normal 0-15 mmHg
  - Measure within 5 cm of fracture
  - All 4 compartments checked
- ICP >30 mmHg (some say 40 or 45 mmHg)
- Pressure differential (diastolic BP – ICP) <30 mm Hg



Promising Technology?

- Near-Infrared Spectroscopy
  - Detects muscle deoxygenation
  - Noninvasive optical technique
  - Real time recording

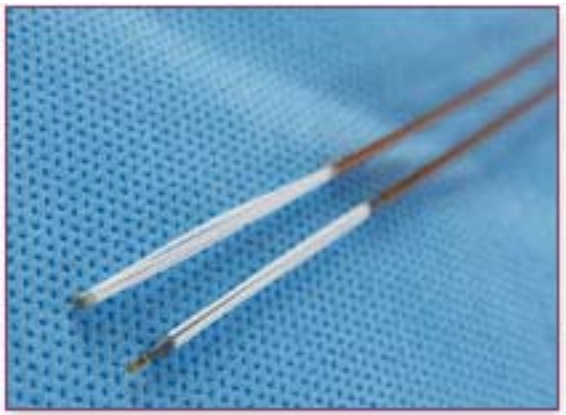


- pH monitoring
- Biomarker
  - To identify impaired muscle metabolism
- Ultrasound

Predicting Acute Compartment Syndrome (PACS): The Role of Continuous Monitoring

Andrew H. Schmidt, MD, Michael J. Bosse, MD,† Katherine P. Frey, RN, MPH,‡ Robert V. O'Toole, MD,§ Daniel J. Stinner, MD,||¶ Daniel O. Scharfstein, ScD,** Vadim Zipunnikov, PhD,** Ellen J. MacKenzie, PhD,‡ and METRC*

- Continuous intramuscular pressure
  - Currently under study
  - Twin Star™ microporous catheter technology
  - Continuous monitoring
    - And withdrawal of fluid

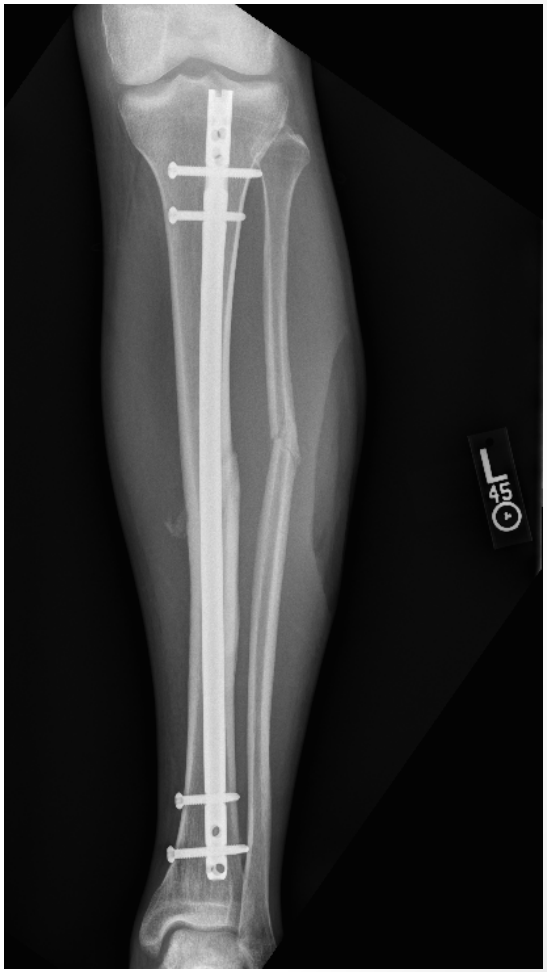


Low Index of Suspicion

"A conglomeration of signs and symptoms, one of which may be an increase in intra-compartmental pressure."

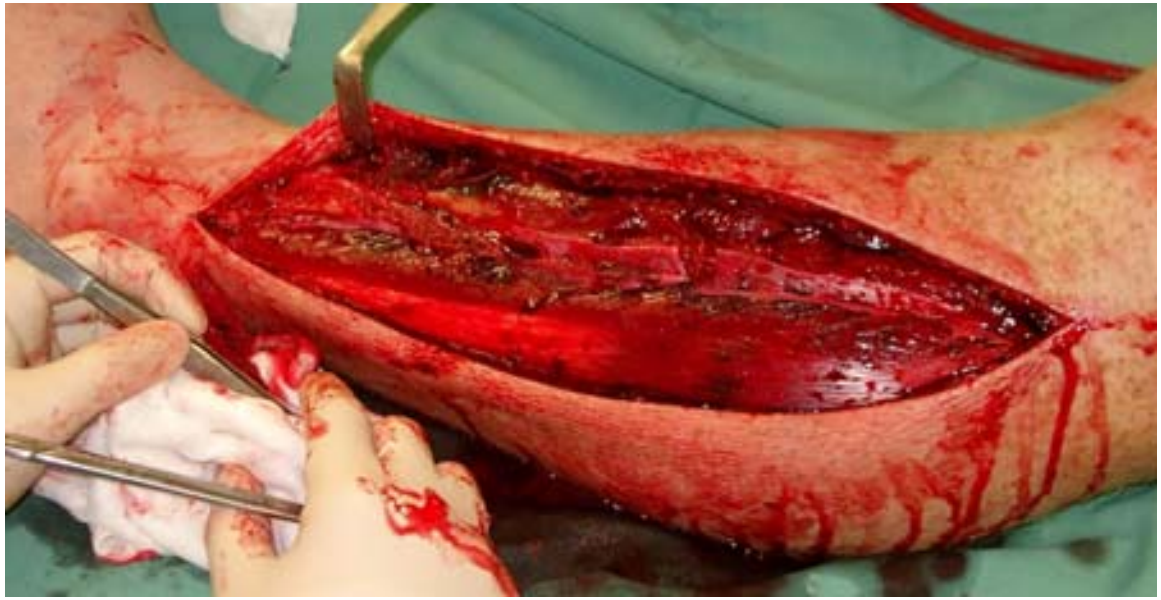
Back to Our Soccer Player

Day	Events
Overnight	Pain rating 6-8 out of 10 3 doses of narcotics
POD 2	Anterior compartment more swollen and less compressible. Frank pain with passive flexion of toes. Discomfort with toe dorsiflexion
Ortho Resident Note:	"Concern for ACS, made NPO, Attending notified, OR booked"



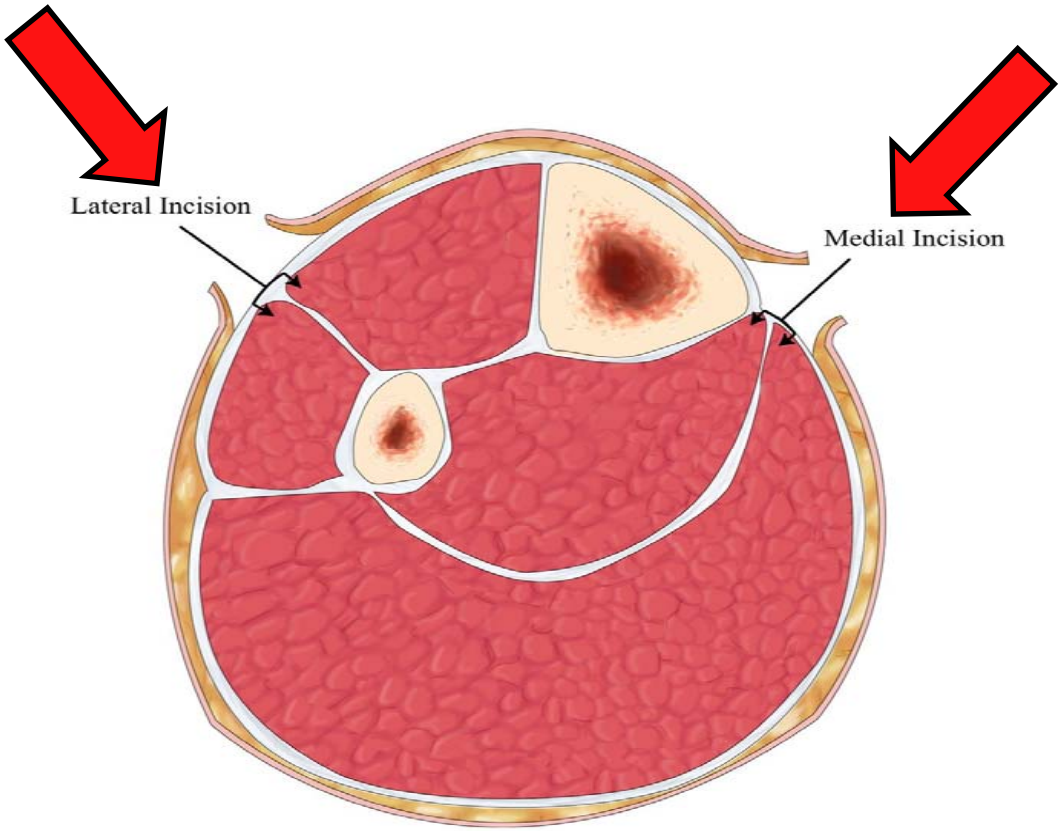
Treatment of ACS

- Immediate operative intervention
  - Release the fascial compartments
  - Reverse ischemia
  - Prevent necrosis
    - Excise necrotic muscle
    - Necrosis will occur after 6-8 hours of inadequate perfusion



Lower Leg Fasciotomy

- Release all 4 compartments
  - 2 incision fasciotomy (Mubarak)
  - Single incision (Matsen)



Nursing Care

- Maintain BP
  - IVF
- Supplemental Oxygen
- Do not elevate extremity
- Prepare for OR
  - NPO
  - Consent
  - Patient/family education

Just Got Complicated

- Pain control
- Second (or third) surgery
- Multiple teams
- Nutritional needs
- Cosmetic results
- Long hospital stay
- Cost

(a)

(b)

Post Release

- Open wound bed
  - Infection
  - Pain
- Dressings
  - Negative pressure wound therapy
- Definitive closure
  - Primary closure
  - Skin grafting within 7-10 days
- Delayed surgical fixation

Contents lists available at ScienceDirect

Injury

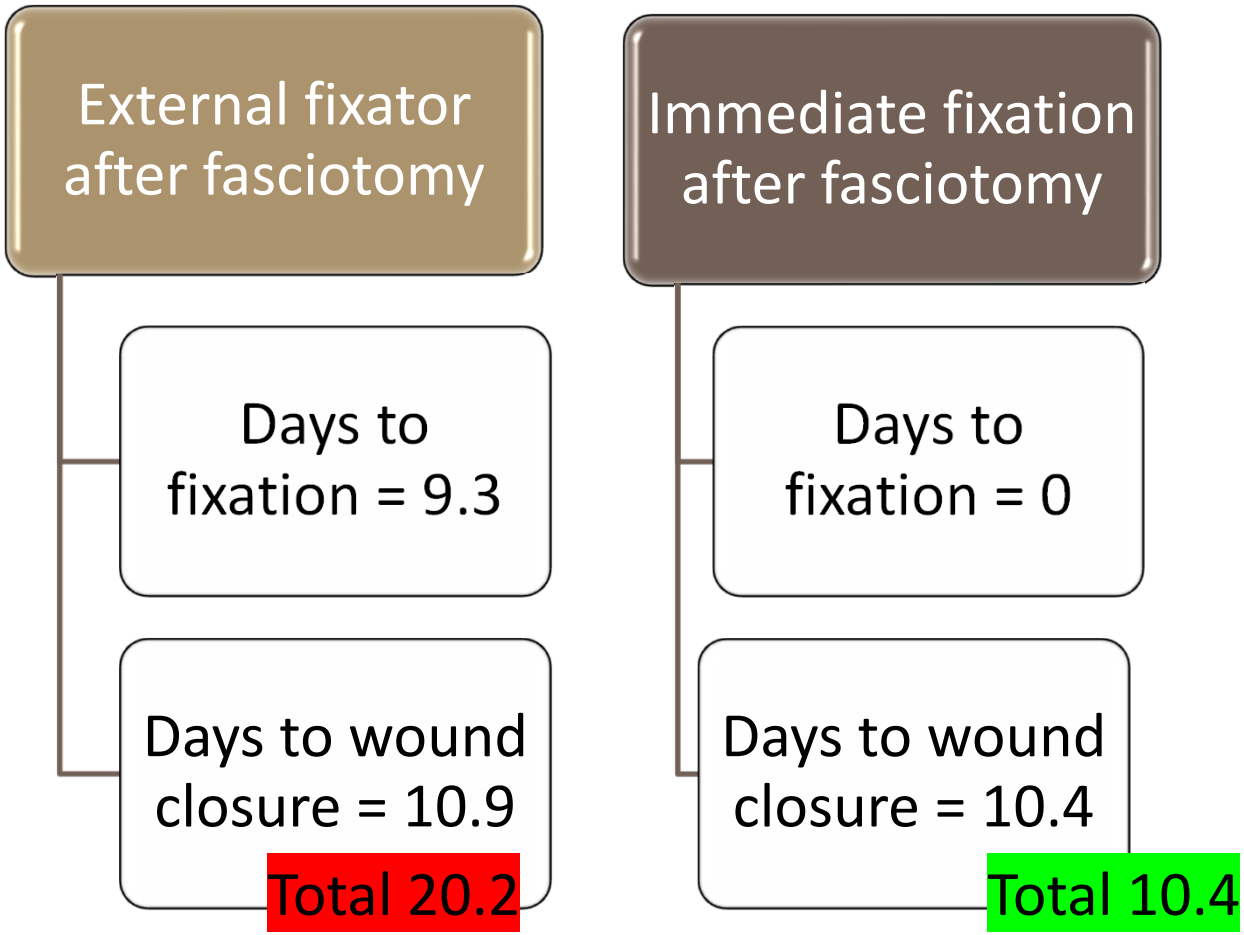
journal homepage: www.elsevier.com/locate/injury

Full length article

Is external fixation needed for the treatment of tibial fractures with acute compartment syndrome?

Tae Hun Kim, Jun Young Chung, Keun Su Kim, Hyung Keun Song*

Department of Orthopedic Surgery, Ajou University School of Medicine, Suwon, Republic of Korea



Post Fasciotomy

- Continue to assess for compartment syndrome
  - ACS can be present after inadequate release

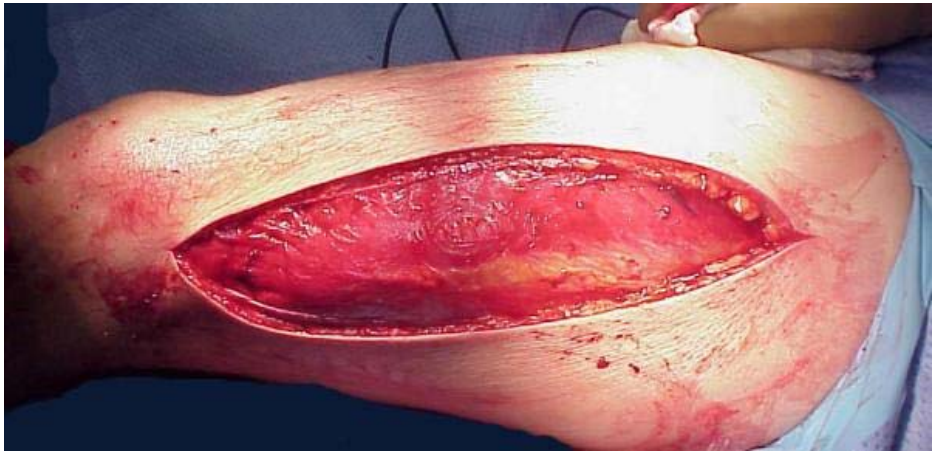
How did we do? SOC Met?

- Initial treatment with bivalved cast

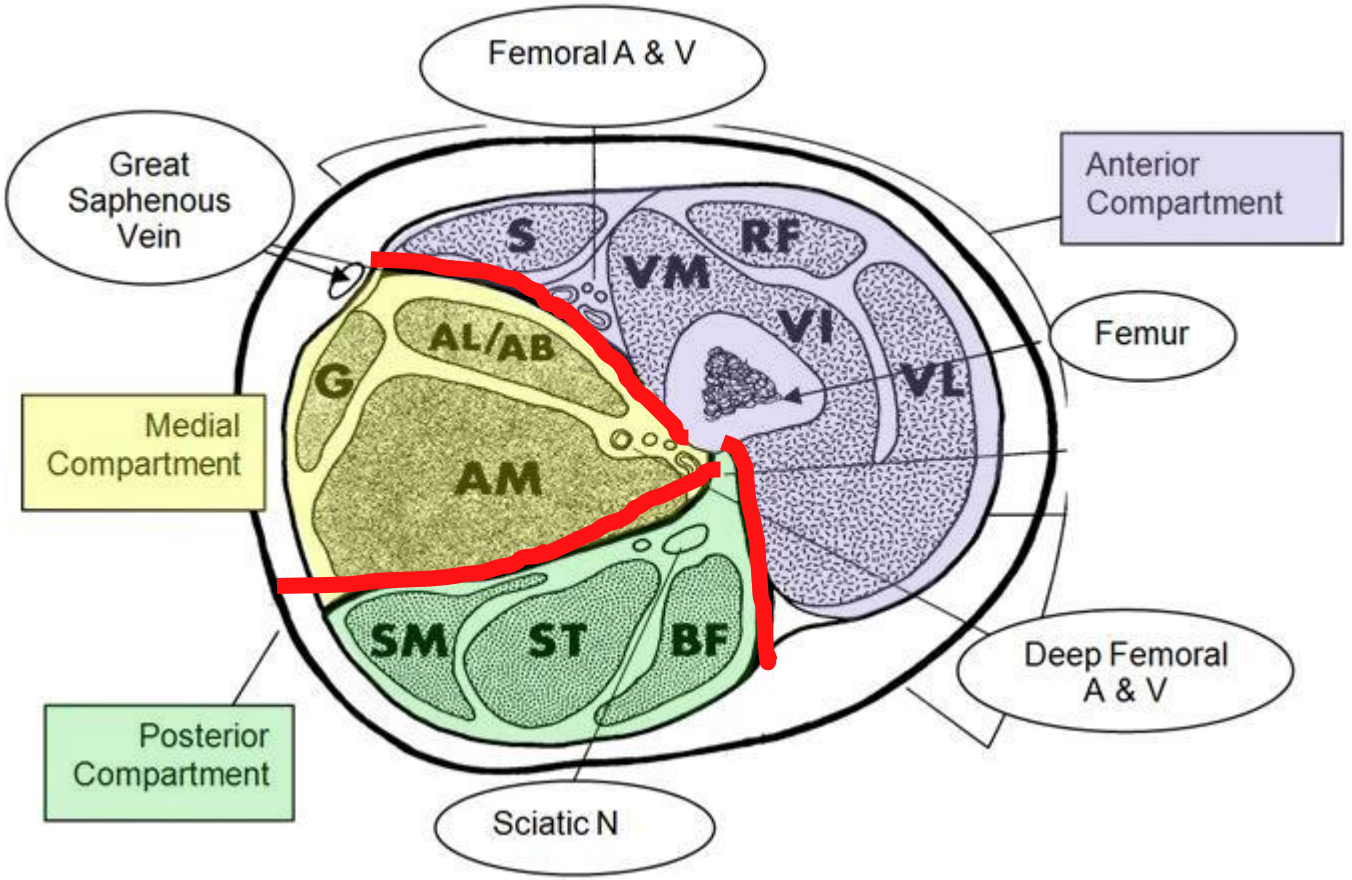
- High index of suspicion
  - Frequent neurovascular checks
- Immediate suspicions with increased pain
- Immediate actions

Case # 2

- Left open midshaft femur fx, Left acetabular fx, multiple fx of left sup/inf rami
- *"Thigh swollen but compartments soft"*
- Undergoes coil embolization of left obturator branch of pelvis
- ORIF of femur
  - Tense compartments noted, fasciotomy done, large hematoma evacuated from left thigh



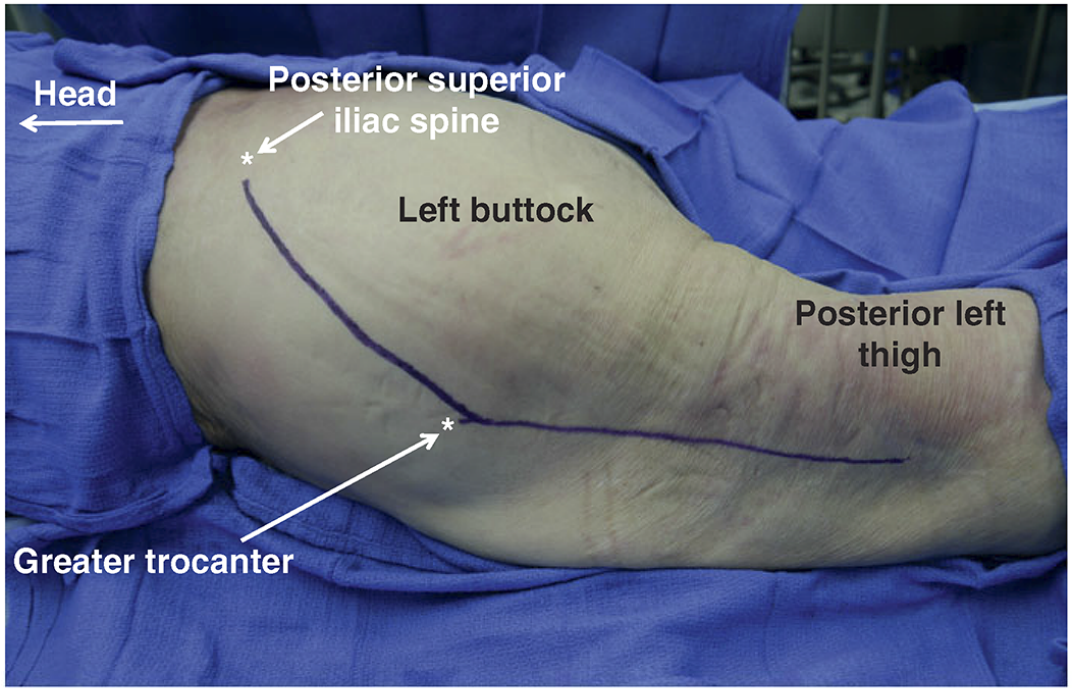
Upper Leg Compartments



Case #3

- 28 year old male IVDA
- Fell down a flight of stairs
- Laid there overnight
- ACS of left forearm and left gluteal
  - Fasciotomies performed

(a)



(b)

Heroin-Related Compartment Syndrome: An Increasing Problem for Acute Care Surgeons

MATTHEW BENNS, M.D., KEITH MILLER, M.D., BRIAN HARBRECHT, M.D., MATTHEW BOZEMAN, M.D., NICHOLAS NASH, M.D.

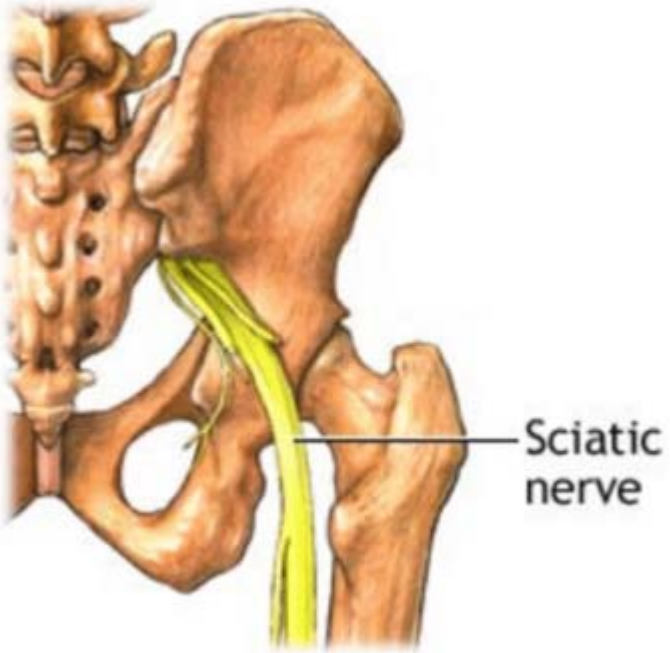
From the Department of Surgery, University of Louisville SOM, Louisville, Kentucky

Gluteal Compartment Syndrome

- Tenderness over buttock
- Pain with hip flexion
- Paresthesia in distribution of sciatic nerve

- Associated with positioning
  - Surgical
    - Hip arthroscopy
  - Unconscious

- Anticoagulated

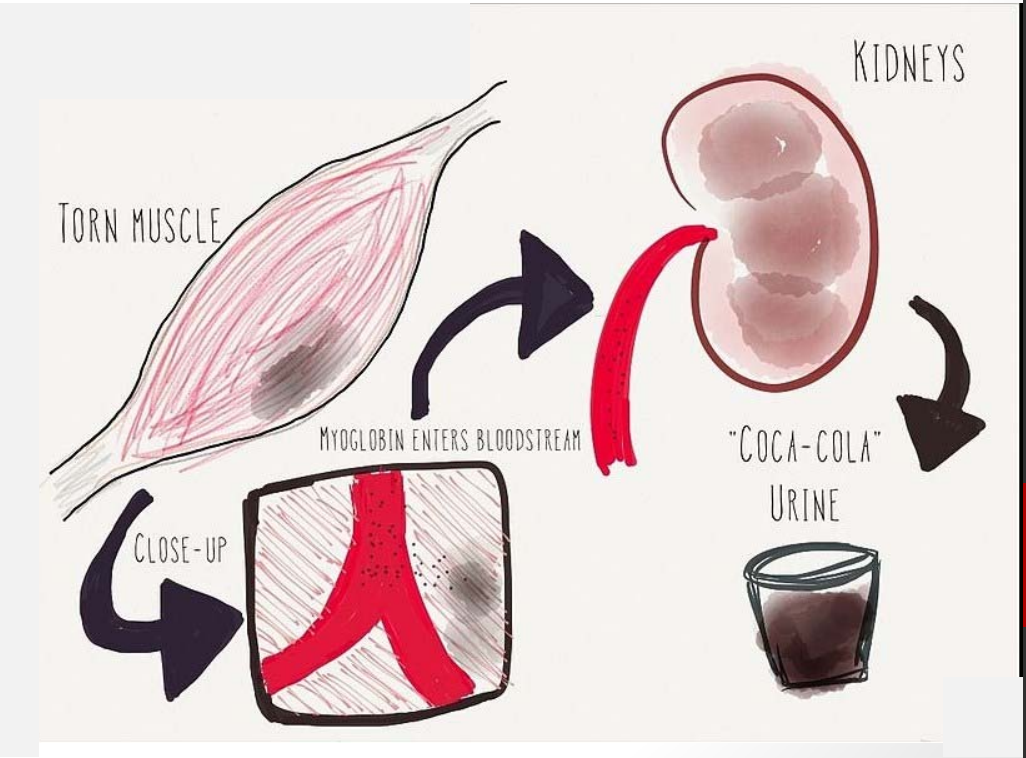


Rhabdomyolysis

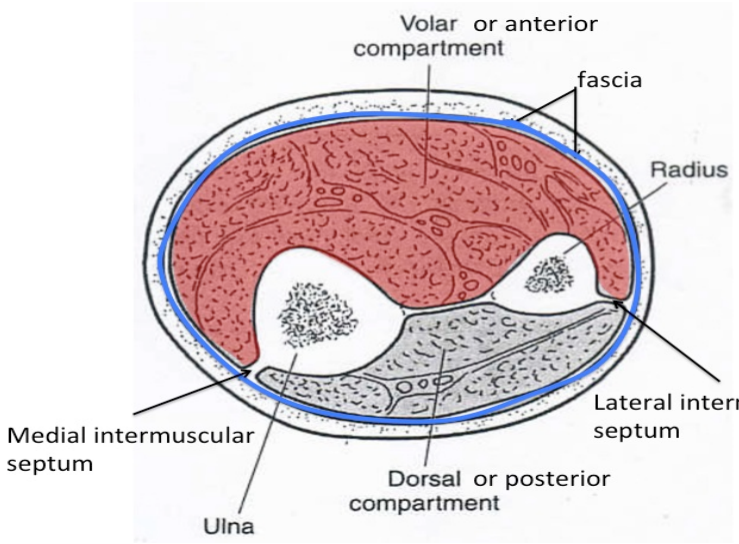
- Skeletal muscle damage → myoglobin leak → toxic to kidney
  - Can cause hypovolemia, hyperkalemia, metabolic acidosis, acute renal failure, and DIC

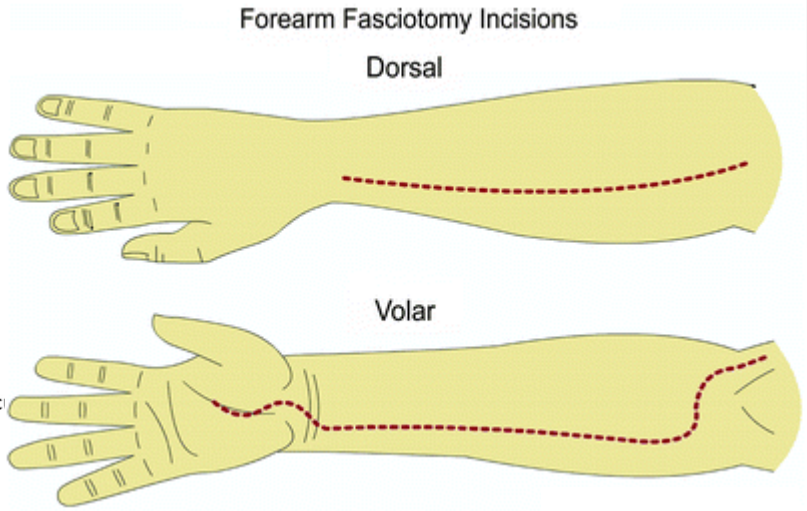
- Immobilization
- Major blunt trauma
- Crush injury

- IV Fluids
- Cardiac monitoring



Upper Extremity ACS





- Forearm is second most frequent site (after lower leg)
- Correlation between ACS and OTA/AO fracture classification *(Auld, et al 2017)*
- Open fractures, soft tissue, pedestrians struck, crush injury

Case 4: Delayed presentation

- 44 year old male presents to community hospital after a car on jack fell onto his arm
- Arm swollen, no fractures, + pulses, decreased sensation, motor intact

- Transfer to Trauma Center
  - Injury 1pm, transfer 3pm, arrive TC 5pm, Fasciotomy 6pm

- Return of most sensation

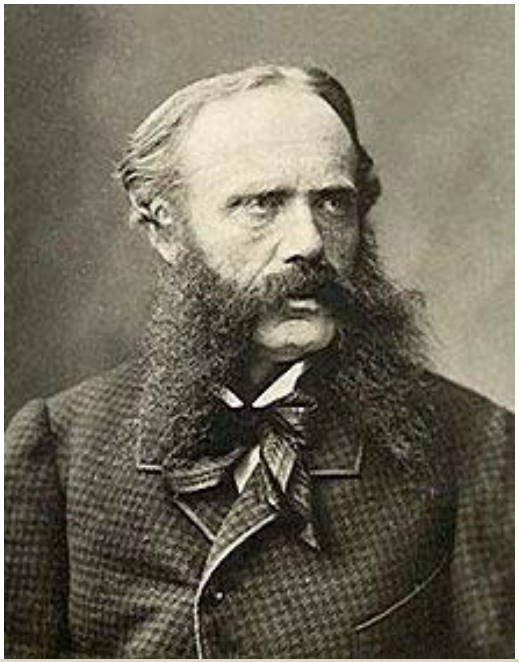
- "Delayed" fasciotomy is > 12 hours
  - Associated with poor outcome
  - Questionable indication for fasciotomy

Delayed Recognition

- 4.5% complications with early fasciotomy, and 54% with late
- Medical liability
  - Significant risk for legal action
  - Failure to act, poor documentation
- At risk for delay:
  - Patients unable to assist in diagnosis
  - Those with previous vascular injury/insufficiency

Untreated ACS

- Muscle contracture
  - Volkmann's contracture
- Muscle weakness
- Sensory loss
- Infection
- Fracture non-union
- Amputation



Dr. Richard von Volkmann

Incidence

- 5 year
- 6180 adult blunt patients
- 83 cases of ACS (1.3%)

JOURNAL OF SURGICAL RESEARCH • SEPTEMBER 2017 (217) 131–136

Available online at www.sciencedirect.com

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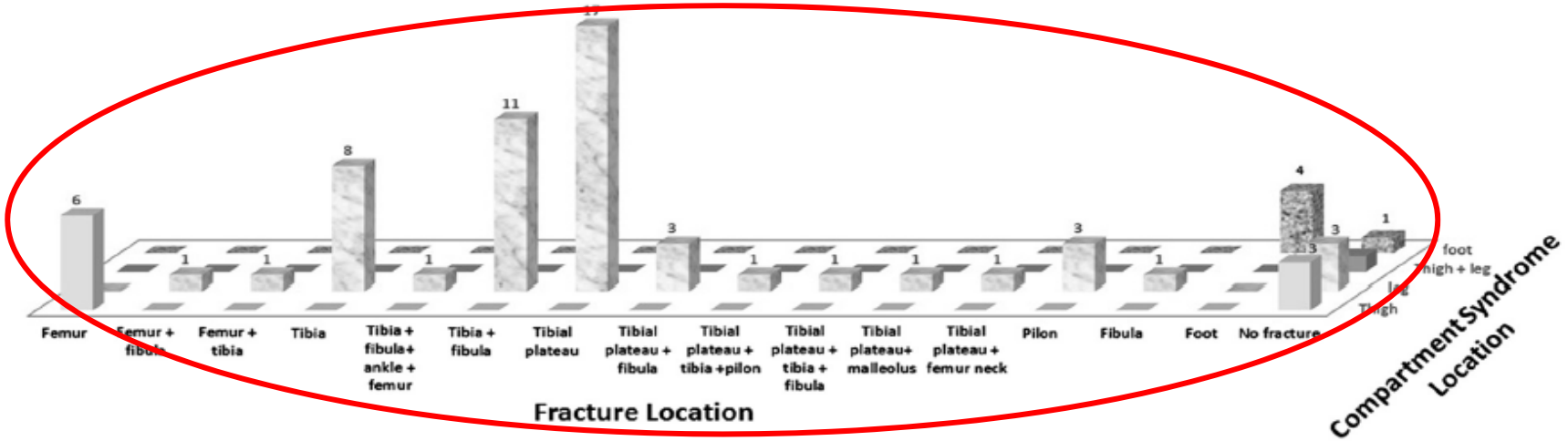
journal homepage: www.JournalofSurgicalResearch.com

Association for Academic Surgery

Extremity compartment syndrome following blunt trauma: a level I trauma center's 5-year experience

Daniel Zuchelli, BS,[a] Nicholas Divaris, MD,[b] Jane E. McCormack, RN,[a] Emily C. Huang, MS,[a] Neeta D. Chaudhary, MD, PhD,[a] James A. Vosswinkel, MD,[a] and Randeep S. Jawa, MD[a,]*

[a] *Division of Trauma, Department of Surgery, Stony Brook University School of Medicine, Stony Brook, New York*
[b] *Department of Orthopedic Surgery, Stony Brook University School of Medicine, Stony Brook, New York*



Case Reports

- Reperfusion following ischemia
- Intraosseous Infusions
- Tourniquet use
- Statin use
- Extravasation of fluid
- Arterial cannulation
- Bleeding disorders

Compartment Syndrome of the Hand: A Little Thought about Diagnosis

Eric F. Reichman *

Calf Compartment Syndrome associated with the Use of an Intra-osseous Line in an Adult Patient: A Case Report

R Malhotra, MRCS, WL Chua, MRCS, and G O'Neill, FRCS (Tr & Orth)

Iowa Orthop J. 2011; 31: 181–186. PMCID: PMC3215133

GLUTEAL COMPARTMENT SYNDROME AND SUPERIOR GLUTEAL ARTERY INJURY AS A RESULT OF SIMPLE HIP DISLOCATION: A CASE REPORT

Benjamin C Taylor, M.D,* Craig Dimitris, M.D,** Alex Tancevski, M.D, and Jerry L Tran, M.D†

Thigh compartment syndrome during extracorporeal life support

Maximilian Kreibich, MD, Martin Czerny, MD, MBA, Christoph Benk, PhD, Friedhelm Beyersdorf, MD, Bartosz Rylski, MD, *and* Georg Trummer, MD, *Freiburg, Germany*

J Child Orthop (2016) 10:453–460
DOI 10.1007/s11832-016-0766-0

ORIGINAL CLINICAL ARTICLE

Compartment syndrome in infants and toddlers

Alexander Broom[1] · Mathew D. Schur[1] · Alexandre Arkader[2] · John Flynn[2] · Alex Gornitzky[2] · Paul D. Choi[1]

Avoidable Compartment Syndrome! High Index of Suspicion for a Newly Presenting Haemophiliac: A Case Series

A. Niblock, [1,*] K. Donnelly, [2] F. Sayers, [3] P. Winter, [4] and G. Benson [1]

Prevention and Treatment

- Balanced hemostatic resuscitation
- Monitoring of anticoagulant, antiplatelet therapy agents
- Careful patient positioning
- Monitoring IV and arterial catheter sites
- Careful use of regional anesthesia
- Release of any restrictive dressings/bandages/splints/casts
- ‘Prophylactic’ fasciotomy in ‘at risk’ patients

Abdominal Compartment

- 8 fascial compartments in the torso

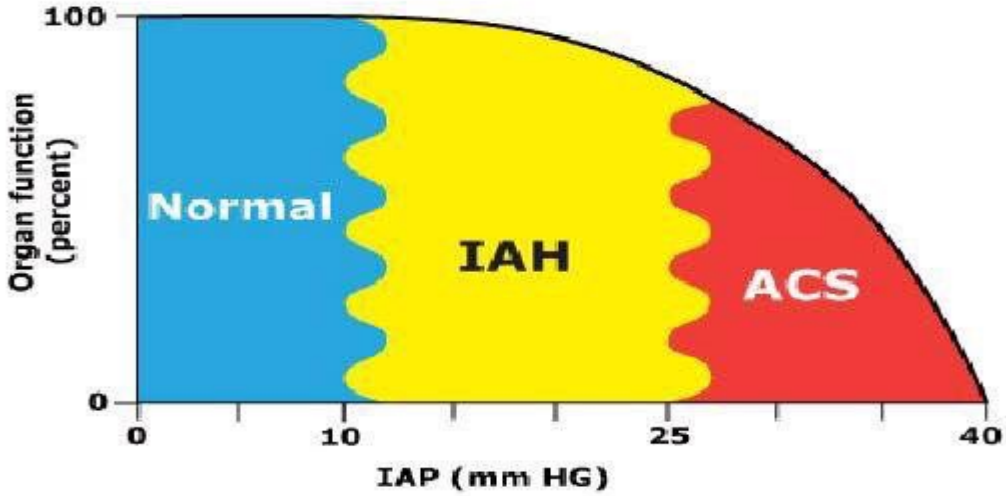
- Causes
  - Resuscitation edema
  - Bowel edema
  - Post op hemorrhage
  - Bowel obstruction
  - Closing under tension
  - Abdominal packing

Abdominal CS

- S/S Multisystem Organ Failure
  - Respiratory failure
  - Decreased urinary output
  - Increased Systemic Vascular Resistance
  - Decreased cardiac output
  - Increased Intra Cranial Pressure

Diagnosis

- Low index of suspicion
- Measure bladder pressure
  - Surrogate for abdominal compartment pressure
  - Protocol for measurement if >10unit transfusion, or >4 hour abdominal procedure



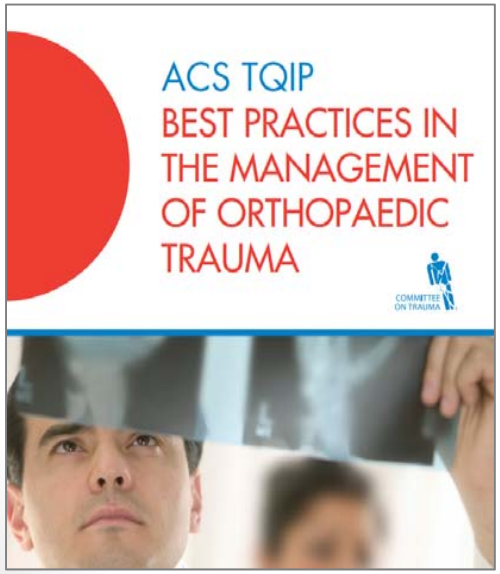
IAH: intra-abdominal hypertension
ACS: abdominal compartment syndrome

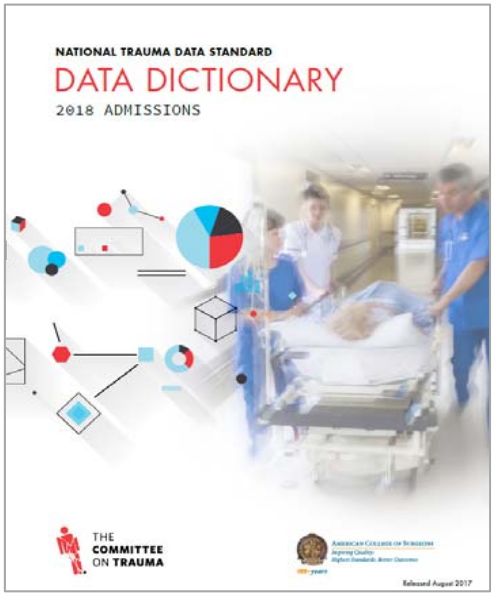
Treatment & Prevention

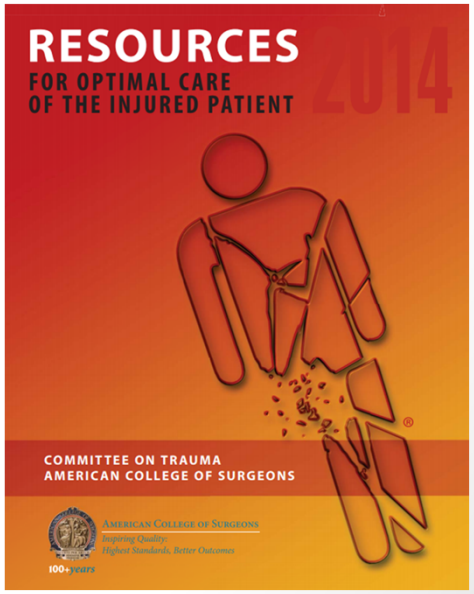
- Opening the abdominal fascia
- Damage control techniques
  - Short surgical time
  - Hemostatic resuscitation
  - Balanced resuscitation
  - Temporary abdominal closure

Programmatic Concerns

- Best Practices
- Complication Rates
- ACS COT Requirements

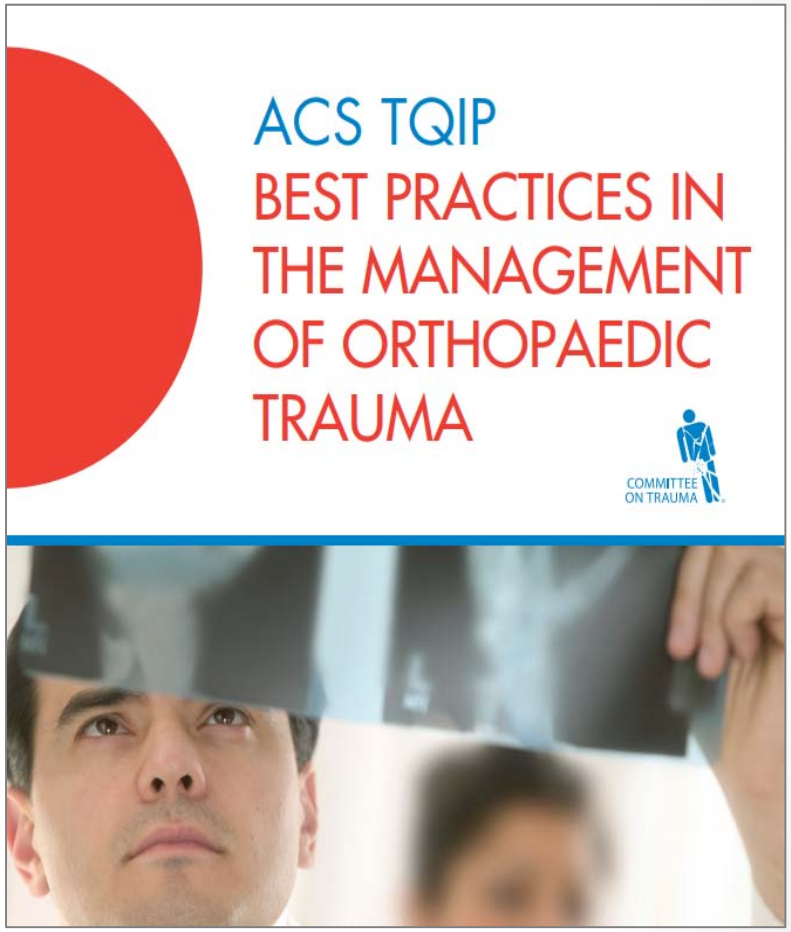






Best Practice

- Dynamic Process
  - Q1-2 evaluation for 24-48 hrs.
  - Sequential physical exam
- Clinical findings are reliable in ruling ACS out
- Unreliable exam may benefit from pressure monitoring



Standardize Assessment

Pediatrics
December 2013, VOLUME 132 / ISSUE 6

A Collaborative System to Improve Compartment Syndrome Recognition

Joshua K. Schaffzin, Heather Prichard, Jennifer Bisig, Peggy Gainor, Krista Wolfe, Lauren G. Solan, Laurie Webster, James J. McCarthy

- Order sets for at risk patients
  - Single click order entry for neurovascular assessment every 2 hours in at-risk patients
  - Increased compliance with monitoring
  - Reduced incidence of complication

HSSJ (2014) 10:143–152
DOI 10.1007/s11420-014-9386-8

HSS Journal®
The Musculoskeletal Journal of Hospital for Special Surgery

REVIEW ARTICLE

Compartment Syndrome: Diagnosis, Management, and Unique Concerns in the Twenty-First Century

Matthew R. Garner, MD · Samuel A. Taylor, MD · Elizabeth Gausden, MD · John P. Lyden, MD

Assess all patients at risk

In a standardized format

all handoffs occur at bedside

Physical Exam

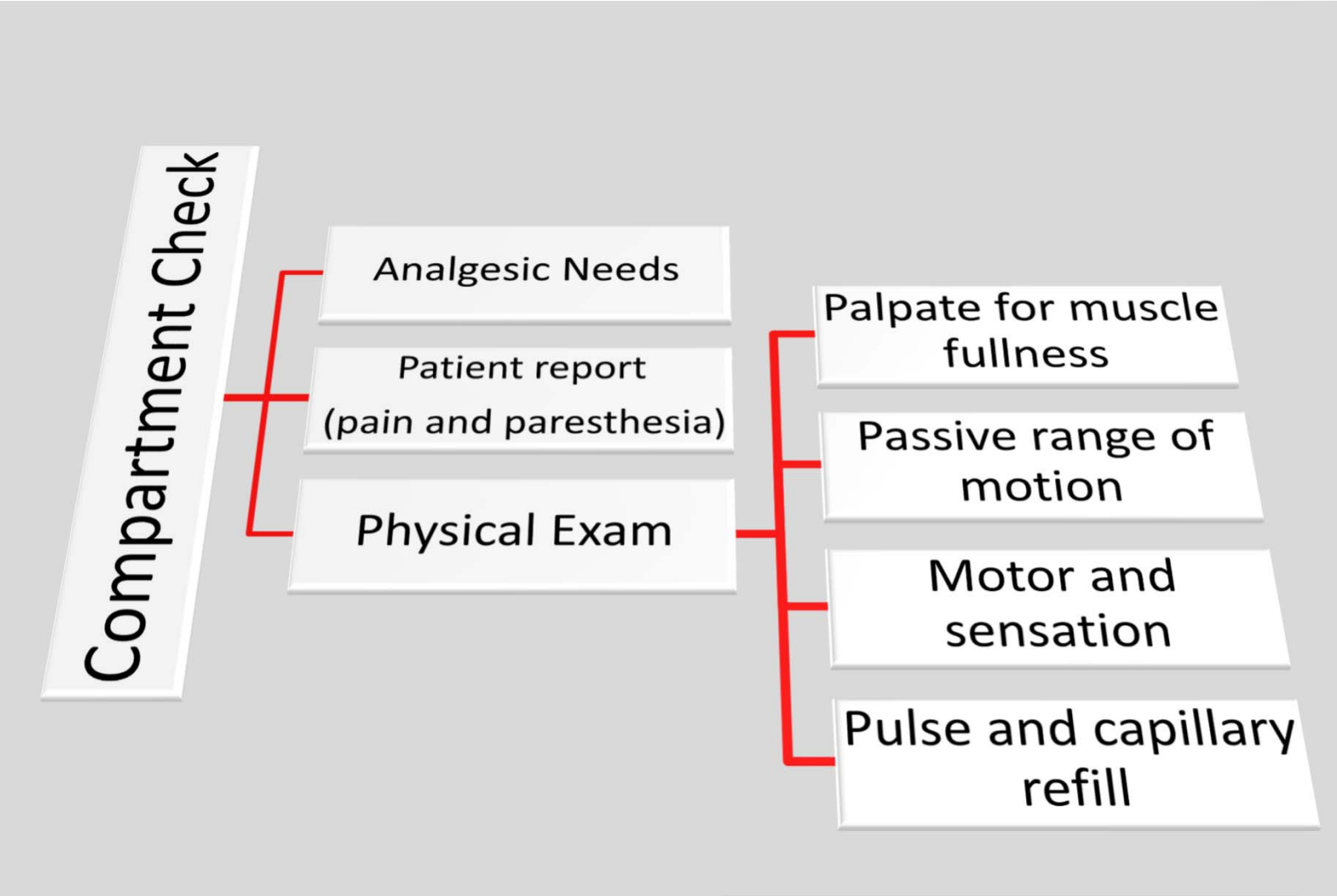
Patient Report

Analgesic Needs

-avoid regional anesthesia

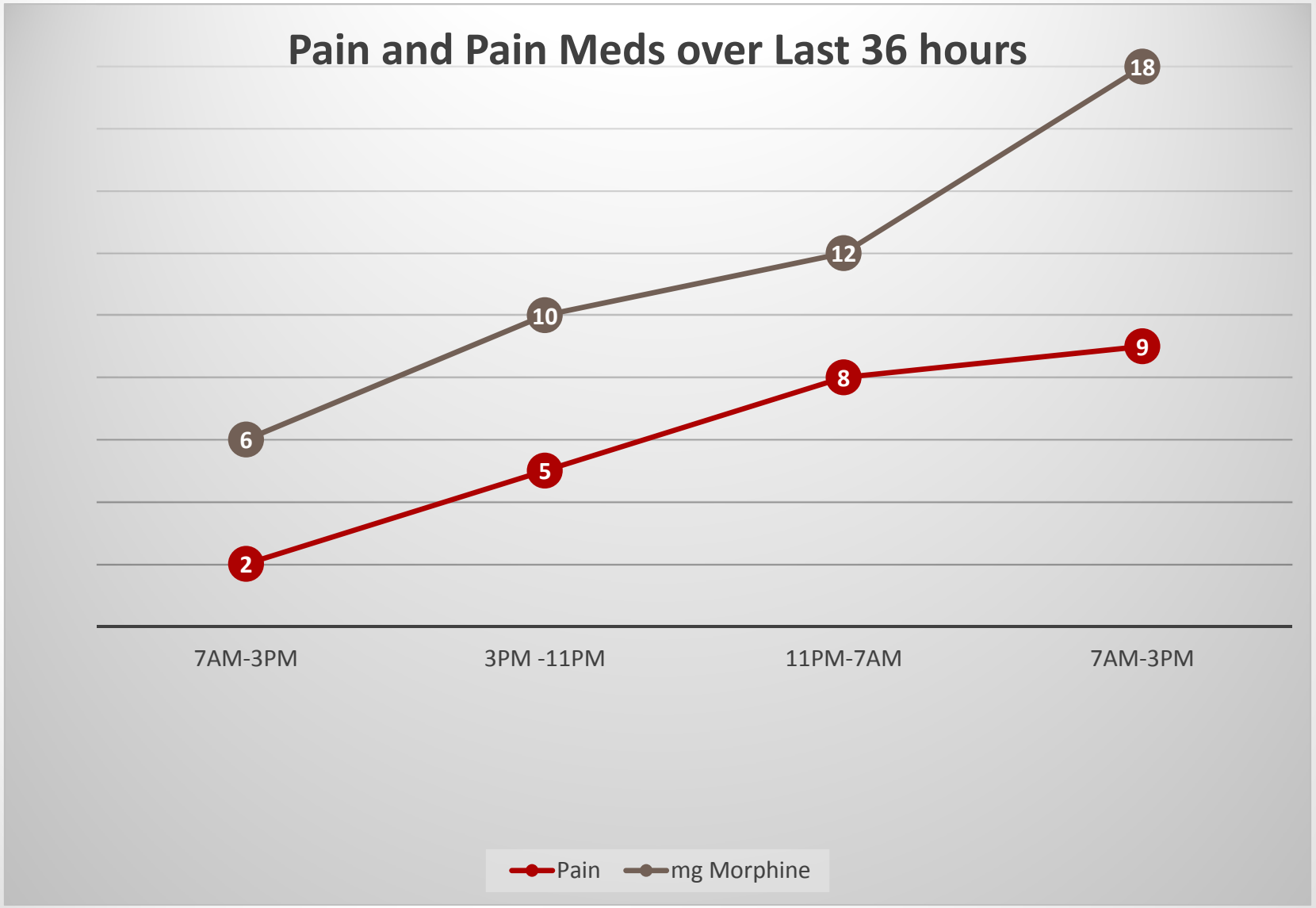
Document

Standardized Exam



Adapted from Garner, et al. 2014

Picture is worth 1000 words



A CULTURE OF SAFETY

- Ability to ‘bump up’ safety concerns

NATIONAL TRAUMA DATA STANDARD

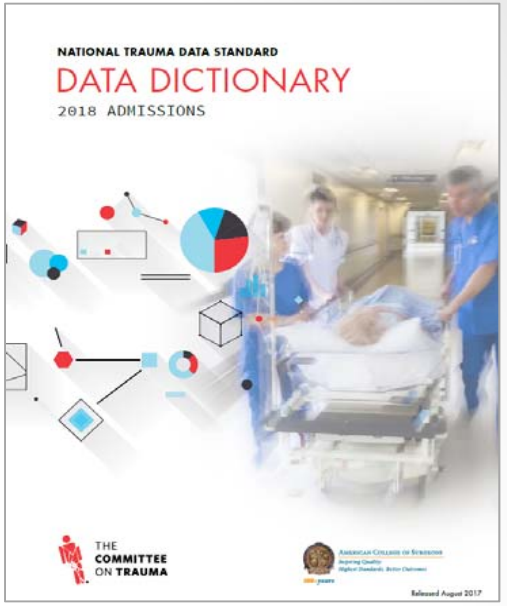
DATA DICTIONARY

2018 ADMISSIONS

HOSPITAL COMPLICATIONS

Definition

Any medical complication that occurred during the patient's stay at your hospital.



- ***Extremity Compartment Syndrome***
  - *"A condition not present at admission in which there is documentation of tense muscular compartments of an extremity through clinical assessment or direct measurement of intracompartmental pressure requiring fasciotomy. ….. Record as a complication if it is originally missed, leading to late recognition, a need for late intervention, and has threatened limb viability."*

Back to our first case

- 23 year old soccer player
- Underwent clinical assessment
- Diagnosis made
- Intervention done

- The NTDS complication of Extremity Compartment Syndrome will **NOT** be assigned

Case #5

- 41 year old male sustains a crush injury to right leg with femur fracture
- During surgery: *"elected to perform a fasciotomy….. After release …….the thigh was soft including the posterior and medial compartments"*
- The NTDS complication of Extremity Compartment Syndrome will **NOT** be assigned

How to Calculate Incidence

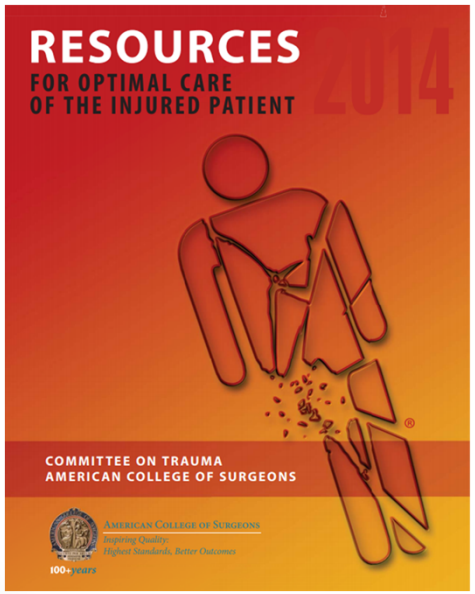
- ICD10 Traumatic Codes
  - *T79.Axxx Traumatic compartment syndrome*
    - *T79.A1xx Upper extremity*
    - *T79.A2xx Lower extremity*
    - *T79.A3XA Abdomen*

- Abbreviated Injury Score (AIS) for Upper and Lower Extremity
  - *812000 Lower extremity*
  - *712001 Upper Extremity*

- ICD10 Procedure codes for Fasciotomy
  - ~~*OJNxxx Subcutaneous tissue and fascia, release*~~
  - *OKNxxx Muscle, release*
    - *Root operation = Release (freeing a body part from an abnormal physical constraint by cutting or using force)*
    - *Body part = Muscle*

An Orthopaedic Emergency

- Immediately available OR required by ACS-COT
  - How does your program track this case?
- Orthopaedic response time
  - Is this 'time sensitive'?
  - How does your program track it?



- ALL trauma patients are at risk
  - Infrequent, but associated with poor outcome
- Remains a clinical diagnosis
  - Complete and consistent patient assessment
- Time sensitive
  - Culture of safety
  - Clear communication
- Programmatic Considerations
  - Specialist response times, OR availability
  - “Complication rate” is likely very low

Thank you

Fire Island, New York