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The Not So Secret Compartments

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

Stony Brook Trauma Center
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

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

- Pallor, Pulselessness, Palpable tenseness, Paresthesia, Pain

- 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

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<td>Ortho Resident Note:</td>
<td>“Concern for ACS, made NPO, Attending notified, OR booked”</td>
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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
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
Immediate fixation after fasciotomy

Days to fixation = 0

Days to wound closure = 10.4

Total 10.4

External fixator after fasciotomy

Days to fixation = 9.3

Days to wound closure = 10.9

Total 20.2
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
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
Incidence

• 5 year
• 6180 adult blunt patients
• 83 cases of ACS (1.3%)
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 Intraosseous Line in an Adult Patient: A Case Report**
R. Mehta, MRCS, W. L. Chu, MRCS, and G. O’Neill, FRCS (Tr & Orth)

**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.

**Avoidable Compartment Syndrome! High Index of Suspicion for a Newly Presenting Haemophiliac: A Case Series**
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 >10 unit 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

• 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

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

Pediatrics
December 2013, VOLUME 132 / ISSUE 6
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

- Compartment Check
  - Analgesic Needs
  - Patient report (pain and paresthesia)
  - Physical Exam

- Palpate for muscle fullness
- Passive range of motion
- Motor and sensation
- Pulse and capillary refill

Adapted from Garner, et al. 2014
Pain and Pain Meds over Last 36 hours

- Pain
- mg Morphine

- 7AM-3PM: 6 mg Morphine, 2 Pain
- 3PM -11PM: 10 mg Morphine, 5 Pain
- 11PM-7AM: 12 mg Morphine, 8 Pain
- 7AM-3PM: 18 mg Morphine, 9 Pain
A CULTURE OF SAFETY

• Ability to ‘bump up’ safety concerns
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