ACUTE COMPARTMENT SYNDROME (ACS)

Mathilde DE QUEIROZ
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France
• First description by Von Volkmann in 1881

• **Pressure increases within a confined closed fascial space** => reduced blood flow and tissue perfusion => ischemia soft-tissue damage => necrosis

• Ischaemia => tissue membrane damage and leakage of fluid through capillary and muscle membranes.

• Tissue damage begins after 4 hours of ischemic time and may be permanent by 8 hours

• **True orthopedic emergency** = emergent fasciotomy => favorable outcome if not delayed
ETIOLOGIES

- Trauma: in an osseofascial compartment of the leg or forearm, but it may occur in the upper arm, thigh, foot, hand

- Non trauma
  - Surgery: osteotomies, fracture
  - Reperfusion, ischaemia, burns, bites and poor positioning for prolonged surgical procedures (particularly lithotomy position)

Incidence
- Rare
- 0.1-10%
- Depends on etiology
Intra-osseous-access-associated lower limb compartment syndrome in a critically injured paediatric patient

EJA 2018

Jake Turner and Karl-Christian Thies

Correspondence

Acute compartment syndrome of the hand secondary to propofol extravasation

Compartment syndrome due to extravasation of peripheral parenteral nutrition: extravasation injury of parenteral nutrition

Hyeon Jin Park, MD1, Young Hoeon Kim, MD2, Hyun Jin Lee, MD3, Soon Cheol Jeong, MD4, Bye Won Kim, MD2, Dong In Sulh, MD

Departments of Orthopaedics and Orthoplastic Surgery, Seoul National University College of Medicine, Seoul. Department of Plastic Surgery, Seoul Metropolitan Government Seoul National University Arterius Medical Center, Seoul. Department of Rehabilitation Medicine, Seoul National University College of Medicine, Seoul.
• Age = 9.7 yo (SD=5.9)
• Trauma: pedestrian vs motor vehicles ++
• Lower leg = 60%
• Forearm = 27%
• Pressure monitoring = 68%
• Pain = 88%
• Paresthesia = 32%
• Mean time from injury to fasciotomy = 25.4h
• Good outcome in 85% (>adult)

• Age = 11.7 yo (SD=7.2)
• Vascular = 28%
• Trauma = 26%
• Post op = 21%
• Exertion = 15%
• Pressure monitoring = 59%
• Pain = 85%
• Swelling = 72%
• Paresthesia = 33%
• Mean time from symptom to diagnosis = 48h (9-96h)
• 31% sequela
• < 3 yo (period study=15 years...)
• 15 ACS
• Average time from injury or hospital
• Admission to fasciotomy was **31.8 h** (range 2.9–136.3 h). > older...
CLINICAL!

The 5 P’s in adults

- **Pain**:
  - Out of proportion
  - With passive stretch of muscles
  - Pain at rest
- Paresthesias
- Palor
- Pulselessness (but damage has been done)
- Paralysis: pain or real?
But in children....

- Pressure, or firm compartments = 80%
- Excess pain = 80%
- Pallor = 33%
- Paresthesia = 7%
- Pulselessness = 40%
- Paralysis = 27%

*Broom J Child Orthop 2016, Bae J Pediatr Orthop 2001*
So in children...

- They not have the cognitive and verbal ability to provide clinical information particularly in an extraordinary situation, resulting in delays in diagnosis and adequate therapy.

- More difficult to achieve cooperation and communication for accurate assessment.

=> The three A’s for children
- Anxiety
- Agitation
- Analgesic requirement: increase in frequency and dosage

Noonan KJ, J Pediatr Orthop. 2010
• Absolute value ? 30 mmHg in adults
• Difference between compartment pressure and diastolic or mean arterial pressure?
• The compartmental perfusion pressure is the difference between the mean blood pressure and the compartmental pressure < 30 mmHg
Normal pressure in children?

**Compartment pressures in children with normal and fractured lower extremities**

Hannah Rachel Bussell, Christoph Alexander Aufdenblatten, Ulrike Subotic, Markus Kalisch, Georg Staubli, Daniel Max Weber, Sasha Sasha Tharakan

Received: 13 October 2018 / Accepted: 30 January 2019

**Compartment Pressures in Children With Normal and Fractured Forearms: A Preliminary Report.**


Differents types of monitor
Absolute values?
Difference?
Position of the patient
Site/fracture of monitoring

Higher Pressure than adults
Monitoring may increase clinical awareness and aid diagnosis in the presence of equivocal clinical findings.
Comparison of NIRS, serum biomarkers, and muscle damage in a porcine balloon compression model of acute compartment syndrome

I Trauma Acute Care Surg 2016
Steven C. Budsberg, DVM, MS, Michael S. Shuler, MD, Megan Hansen, MS, Elizabeth Uhl, DVM, PhD, and Brett A. Freedman, MD, Athens, Georgia

TRAUMA
Continual near-infrared spectroscopy monitoring in the injured lower limb and acute compartment syndrome
AN FDA-IDE TRIAL
Bone Joint J 2018

Near-Infrared Spectroscopy Identifies Compartment Syndrome in an Infant
Joseph D. Tobias, MD* and Daniel G. Hoenschemeyer, MD**

Continuous Near-Infrared Spectroscopy Demonstrates Limitations in Monitoring the Development of Acute Compartment Syndrome in Patients with Leg Injuries
Andrew H. Schmidt, MD, Michael J. Boece, MD, William T. Oldenmeyer, MD, MPH, Robert V. O’Toole, MD, Ellen A. Carroll, MD, Daniel L. Rimmer, MD, David J. Hak, MD, Masheer Karuakar, MD, Renan Harfa, MD, Katherine F. Foy, RN, MS, MPH, (PhD), Yuncal Din, MD, Vedem Zippan-Niilo, PhD, Ellen MacKinnon, PhD, and the Major Extremity Trauma Research Consortium (METRC)*

Utility of Near-Infrared Spectroscopy in the Diagnosis of Lower Extremity Compartment Syndrome
Giovanni Giovanni, MD, Stephen M. Cotes, MD, Margaret Brown, RN, J. Enrico Velez, MD, Mark G. McKenney, MD, and Jill A. Winberg, MPH

And the NIRS?

Depth?
Cut-off?
Reference value?
Cost...
Which analgesia in situation at risk of ACS?

Regional analgesia

Anesthesiologist

VS

Patient analgesia opioid

Surgeon
Regional anesthesia is used to control postoperative pain in adults and children. Injudicious use may mask the primary symptom (pain) of CS. Use of regional anesthesia in patients at high risk for CS is highly discouraged.

(1) There is no current evidence that the use of regional anesthetics increases the risk for ACS or delays its diagnosis in children.

(2) A comprehensive preoperative discussion with the patient’s family and the surgical team should be performed to inform them of this rare but serious complication.
Editorial
What does analgesia mask?

C. LEJUS MD
Service of Anaesthesiology, Hôtel Dieu, C.H.U. Nantes, France

Some current controversies in paediatric regional anaesthesia
Bernard Dalens

Current Opinion in Anaesthesiology 2006,

patient. Since the ‘first’ presenting symptom is the legal reference, some physicians deny adequate care, especially pain relief, to their patients in order not to ‘hide’ pain as a presenting symptom.
Journals of anesthesia

Compartment syndrome diagnosed in due time by breakthrough pain despite continuous peripheral nerve block

H. Munk-Andersen and T. K. Laetuth
Department of Anaesthesia and Intensive Care, Viborg Regional Hospital, Viborg, Denmark

Evolving Compartment Syndrome Not Masked by a Continuous Peripheral Nerve Block
Evidence-Based Case Management
(Reg Anesth Pain Med 2012;37: 393–397)
Benjamin J. Walker, MD, * Kenneth J. Noonan, MD, † and Adrian T. Bosenberg, MBChB, FFA(SA), ‡

The National Pediatric Epidural Audit

Did Continuous Femoral and Sciatic Nerve Block Obscure the Diagnosis or Delay the Treatment of Acute Lower Leg Compartment Syndrome? A Case Report

N. Llewellyn, RN, RSCN, BA* AND A. Moriarty FRCA†
*Acute Pain Service and †Department of Anaesthesia, Birmingham Children’s Hospital NHS Trust, Birmingham, UK
Review article

Does epidural analgesia delay the diagnosis of lower limb compartment syndrome in children?

DOUG J.G. JOHNSON MBChB MRCP FRCA AND GEORGE A. CHALKIADIS MBBS FANZCA FFPMANZCA DA(LON)

Department of Anaesthesia and Pain Management, Royal Children’s Hospital, Parkville, Vic., Australia

- Review: 12 cases with epidural analgesia
- Pain in 100%: out of proportion, increasing analgesic requirements
- Adults: epidural masked ACS because of leak of monitoring or motor block or expectative attitude

Discussion with surgical colleagues prior to operation will identify patients at increased risk of developing compartment syndrome and this should be communicated to all staff involved in perioperative care. These patients should not have epidural local anesthetic analgesia unless the perceived benefits outweigh the risks.

Should epidural analgesia be prescribed, local anesthetic concentrations should be dilute so as to avoid dense sensory and motor blockade. Avoid-

Table 1
‘Red flags’ for impending compartment syndrome

<table>
<thead>
<tr>
<th>Red flags</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing pain in the setting of surgery or injury that predisposes to compartment syndrome</td>
</tr>
<tr>
<td>Pain remote to the site of surgery</td>
</tr>
<tr>
<td>Increasing analgesic use or requirements</td>
</tr>
<tr>
<td>Paresthesia not attributable to analgesia</td>
</tr>
<tr>
<td>Reduced perfusion of painful site</td>
</tr>
<tr>
<td>Swelling</td>
</tr>
<tr>
<td>Pain on passive movement of painful site</td>
</tr>
</tbody>
</table>
Femoral and adductor blocks without sciatic block...

Pain despite epidural have been stoped since 48h.....

Legs ACS / thoracic epidural..........

Per-Arne Lönnqvist*, Claude Ecolleyb, Adrian Bosenbergc, Santhanam Sureshd, and Giorgio Ivanb

However, ischemic and acute nociceptive pain are transmitted by different nerve fibers and if using dilute local anesthetics solutions nociceptive pain is blocked, whereas the sensation and transmission of ischemic pain is preserved. Thus, if significant breakthrough pain occurs in a patient with a previously working continuous regional block, this is almost pathognomonic for ACS.

A delay in the diagnosis of ACS is most usually caused by not properly identifying patients that are at risk of developing ACS and to insufficient postoperative monitoring of these patients.

(1) There is no current evidence that the use of regional anesthetics increases the risk for ACS or delays its diagnosis in children.

(2) A comprehensive preoperative discussion with the patient’s family and the surgical team should be performed to inform them of this rare but serious complication.
(a) Single shot for both peripheral and neuraxial blocks: use 0.1–0.25% bupivacaine, levobupivacaine, or ropivacaine concentrations because they are less likely to mask ischemic pain and/or produce muscle weakness than more concentrated solutions (Evidence B4);
(b) For continuous infusions, bupivacaine, levobupivacaine, or ropivacaine concentrations should be limited up to 0.1%;
(c) In cases of patients having tibial compartment surgery or other high-risk surgeries for compartment syndrome, restricting both volume and concentration in sciatic catheters is advisable;
(d) The use of local anesthetics additives should be with caution because they can increase the duration and/or density of the block;
(e) High-risk patients should have appropriate follow-up by acute pain services to allow early detection of potential signs and symptoms;
(f) If ACS is suspected, compartment pressure measurements should be urgently assessed.
And what about Patient Controlled Analgesia Opioids?

Compartment syndrome and patient-controlled analgesia in children--analgesic complication or early warning system?
Yang j¹, Cooper MG.

Acute compartment syndrome masked by intravenous morphine from a patient-controlled analgesia pump.
Harrington P¹, Bunola J, Jennings AJ, Bush DJ, Smith RM.

Does patient controlled analgesia delay the diagnosis of compartment syndrome following intramedullary nailing of the tibia?
Richards H¹, Langston A, Kulkarni R, Downes EM.

DOES PATIENT-CONTROLLED ANALGESIA LEAD TO DELAYED DIAGNOSIS OF LOWER LIMB COMPARTMENT SYNDROME?
There is a lack of appreciation by some authors of the importance of the pharmacology of epidural analgesia in the clinical presentation.
Editorial

What does analgesia mask?

C. LEJUS MD
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Pediatric data related to complications masked by efficient analgesia are rare. The rationalization is most likely that our young patients still frequently suffer from too light analgesia. The masking of surgical symptoms or complications does not really constitute a problem as long as a regular, clinically appropriate examination is carried out. The monitoring includes the evaluation of postoperative pain with scores according to the age. Any unusual postoperative painful episode or one not regressing with usual treatment must lead to the search for a possible complication. The use of self-administered
After a serious safety event involving a failure to diagnose ACS at our institution, we identified a lack of awareness about ACS among physicians and nurses and inconsistency with orders and monitoring of patients at greatest risk for developing ACS.

- Create a reliable system for recognition of patients at risk and monitoring for ACS that could withstand frequent provider turnover.
- Individual interventions, including pocket card distribution, electronic medical record order set, and direct discussion by team leaders,
- Neurovascular assessment was defined as an order for neurovascular assessment every 2 hours.
- Proper order entry increased from 23% at baseline to 90%.
CONCLUSION

- Rare but real emergency
- Know the situation at risk
- Monitoring patients at high risk
- Education of medical and paramedical staff for supervision
  - Lack of compartment pressure monitoring and inadequate assessment and observation are the most common factors associated with a missed diagnosis.

- **Discussion** with surgeons for analgesia strategy
  - **Balance risk/benefit: the optimal analgesia**
  - Monitoring
  - Education
  - Regional anesthesia is not a contraindication
  - Avoidance of dense sensory or motor block and unnecessary sensory blockade
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MONTPELLIER

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