Joint Trauma System

Extremity Compartment Syndrome and the Role of Fasciotomy in Extremity War Wounds

Clinical Practice Guideline (CPG) Training

Joint Trauma System Trauma Care Educational Program

Disclosure/Disclaimer

- No financial disclosures
- The view(s) expressed herein are those of the author(s) and do not reflect the official policy or position of Brooke Army Medical Center, the U.S. Army or Air Force Medical Department, the U.S. Army or Air Force Office of the Surgeon General, or the Department of Defense or the U.S. Government.

Agenda

- Purpose
- Summary
- Background
- Signs and symptoms
- Evaluation
- Treatment
- CS algorithm
- Performance Improvement (PI) monitoring
- References
- Appendices
- Contributors

Purpose

- These slides are based on the JTS Acute Extremity Compartment Syndrome (CS) and the Role of Fasciotomy in Extremity War Wounds CPG which guides providers in the evaluation and treatment of patients with extremity war wounds, including the role of prophylactic and therapeutic fasciotomy
- Date of CPG publication: 25 Jul 2016
- JTS CPGs are evidence-based guidelines developed by subject matter experts in the military and civilian communities. CPGs are compiled from DoD Trauma Registry data, health data abstracted from patient records and after action reports.
- Information contained in this presentation is only a guideline and not a substitute for clinical judgment.

Summary

- The operational definition of compartment syndrome (CS) is a clinical syndrome wherein high pressure within a myofascial space reduces perfusion and decreases tissue viability.
- Therapeutic fasciotomy is indicated for established CS.
- Prophylactic fasciotomy is indicated when there is a substantial risk of compartment syndrome.
- CS requires immediate operative intervention.
- Prophylactic compartment syndrome is indicated if there is substantial risk of compartment syndrome.

Background

- Military trauma patients in general have higher overall trauma burdens and occur in remote locations compared to civilian trauma.
  - Compartment syndrome is a common and disabling problem in extremity war injuries.
  - 15% of all military orthopedic trauma casualties require a fasciotomy.
- Compartment syndrome is a clinical syndrome where high pressure with a myofascial space reduces perfusion and decreases tissue viability.
  - **Therapeutic Fasciotomy Indication**: Established compartment syndrome
  - **Prophylactic Fasciotomy Indication**: Substantial risk of compartment syndrome

Background

- Compartment syndrome can be lethal. Early diagnosis challenging.
- Prophylactic fasciotomy used in “at risk” fractures and patients with prolonged ischemia/following limb perfusion.
  - Difficulties associated with monitoring a patient’s physical exam during lengthy transport combined with inability to intervene during time should be considered.

Background

Risks for Acute Traumatic Compartment Syndrome	
Decreased Compartment Volume	▪ Tight cast or dressing, closure of prior fasciotomy, excess traction ▪ External limb compression or crush particularly in obtunded or incapacitated casualty ▪ Frostbite, burns or electric injury (may include escharotomy)
Increased Compartment Contents	▪ Edema accumulation: embolism, intravascular thrombosis, replantation, venous tourniquet, injections, extravasation, infiltration, ergotamine ingestion, ischemia-reperfusion, swelling, artery injury or spasm, revascularization procedures, prolonged arterial tourniquet use, shock hypoperfusion, angiography and catheterization, limbs positioned well above heart, mal-positioned joints (ankle dorsiflexion,) or stretched muscles ▪ Prolonged immobilization and limb compression particularly with obtunded or drugged casualty, some surgical positioning ▪ Hemorrhage, hemophilia, coagulopathy, anticoagulation, vessel injury ▪ Large volume crystalloid resuscitation ▪ Fractures particularly tibia fractures in adults, supracondylar humerus fractures in children displaced, comminuted, or open fractures increase hemorrhage, swelling, and CS risk ▪ Popliteal cyst, long leg brace

Signs & Symptoms

- **Pain out of proportion:** Most important. Often obscured in combat casualties due to altered mental status/heavy sedation.
- **Palpably tense muscle compartments:** Specific. Not sensitive. Highly subjective.
- **Paralysis:** Can be due to direct neural trauma.
- **Paresthesia:** Can be due to direct neural trauma.
- **Pulselessness:** Late and ominous sign in civilian trauma. Occurs more commonly and potentially within minutes in military trauma.

Evaluation

- Tissue edema peaks at 24-48 hours, but vigilance should be maintained for a week.
  - Delayed presentation higher concern in sequential surgical procedures, ongoing resuscitation, and/or ischemia-reperfusion.
- Passive stretch pain, palpation of muscles for tenseness and pulse quality combined with index of suspicion make up mainstay of evaluation.
  - Most caused by open fractures, even with traumatic fasciotomy.
  - Tibia fracture associated with 45% of compartment syndromes.
- Suggest serial exams hourly when risk is high and less frequently when risk is low.

Evaluation

- Pressure measurement of compartments has significant limitations and is not recommended for routine use in theatre.
- In the absence of crush injury, fracture, multiple trauma, over resuscitation, electoral injury, or similar injury, prophylactic fasciotomy on burned extremities are not indicated.

High risk injury for CS.

Treatment

- Diagnosis of compartment syndrome requires immediate intervention.
  - Delayed or incomplete compartment syndrome has been associated with increased mortality and need for amputation
- Any limb at risk of compartment syndrome in an austere location should undergo prophylactic fasciotomy when they reach a fixed surgical facility.

Treatment

- Patients with compartment syndrome that experience delayed evacuation over 12 hours with nonviable muscle should not have fasciotomy performed.
  - Situation associated with increased risk of complication.
  - Patients are best treated with appropriate resuscitation, urine alkalization, mannitol use, and intensive support.
- Once decision is made to perform compartment release, all compartments in the affected anatomic region are over their entire length.

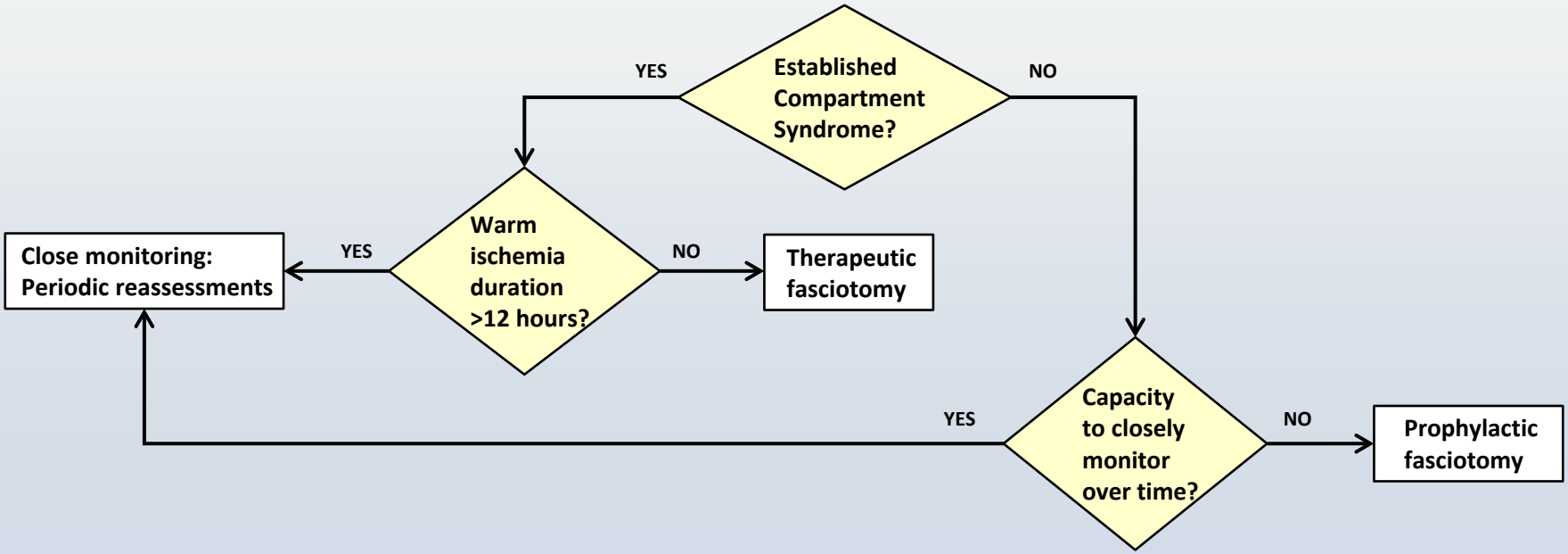
Treatment

- Surgical expectations during fasciotomies:
  - **Calf**: Two incision technique
  - **Forearm**: Superficial and deep volar compartments through incision from lacertus fibrosus to carpal tunnel
  - **Foot Fasciotomy**: Consequences of fasciotomy can be worse than compartment syndrome. Carefully weigh advantages and disadvantages.
- Most common missed compartment syndromes are anterior and deep posterior compartments of the calf.
- Most common incomplete releases are in the calf.

Fasciotomy of the calf in progress.

CS Algorithm

Risk Assessment for Extremity Compartment Syndrome



PI Monitoring

- Population of Interest
  - All patients diagnosed with compartment syndrome
  - All patients with limb AIS ≥ 3 or tourniquet time > 2 hrs
- Intent (Expected Outcomes)
  - Compartment syndrome is diagnosed and treated prior to tissue necrosis.
  - When fasciotomy is indicated, a complete fasciotomy is performed.
  - Tourniquet times are documented.
  - The use of prophylactic fasciotomy is minimized.

PI Monitoring

- Performance/Adherence Metrics
  - Number and percentage of patients diagnosed with compartment syndrome who receive fasciotomy performed at the same role of care (or have reason for delay documented).
  - Number and percentage of patients undergoing fasciotomy who require debridement of necrotic muscle in the affected limb.
  - Number and percentage of patients with tourniquet placed who have tourniquet times (placement and removal) documented.
  - Number and percentage of patients who undergo fasciotomy who do not have a diagnosis of compartment syndrome.
- Data Source
  - Patient Record
  - Department of Defense Trauma Registry (DoDTR)

References

1. Shore BJ, Glotzbecker MP, Zurakowski D, et al Acute compartment syndrome in children and teenagers with tibial shaft fractures: incidence and multivariable risk factors. J Orthop Trauma. 2013 Nov; 27(11):616-21.
2. Ziran BH, Becher SJ. J Orthop. Radiographic predictors of compartment syndrome in tibial plateau fractures. Trauma. 2013 Nov; 27(11):612-5.
3. Park S, Ahn J, Gee AO, et al. Compartment syndrome in tibial fractures. J Orthop Trauma. 2009 Aug; 23(7):514-8.
4. McQueen MM, Duckworth AD, Aitken SA, et al Predictors of compartment syndrome after tibial fracture. J Orthop Trauma. 2015 Apr 9.
5. Shadgan B, Pereira G, Menon M, et al Risk factors for acute compartment syndrome of the leg associated with tibial diaphyseal fractures in adults. J Orthop Traumatol. 2014 Dec 28.
6. Kragh JF Jr, Wade CE, Baer DG, et al Fasciotomy rates in operations enduring freedom and Iraqi freedom: association with injury severity and tourniquet use. Orthop Trauma. 2011 Mar; 25(3):134-9.
7. Ritenour AE, Dorlac WC, Fang R, et al. Complications after fasciotomy revision and delayed compartment release in combat patients. J Trauma. 2008; 64(2 Suppl):S153-61; discussion S161-2. Landstuhl cohort. Inadequate fasciotomy risks mortality. Surgeons should have this.
8. Mubarak SJ, Hargens AR. Compartment Syndromes and Volkmann's Contracture. Saunders, Philadelphia, 1981.
9. US Army, Medical Research and Materiel Command. Compartment Syndrome: Diagnosis and Surgical Management DVD, 2008. 90 minutes, How to do surgery.
10. Office of The US Army Surgeon General, Health Policy and Services (HP&S) Directorate, All Army Action Order, Complications after fasciotomy revision and delayed compartment release in combat patients. 15 May 2007. Ritenour message.
11. Klenerman L. The Tourniquet Manual. London: Springer; 2003. The only book on tourniquets which increase the risk of compartment syndrome somewhat especially if used incorrectly such as a venous tourniquet.
12. Reis ND. Better OS. Mechanical muscle-crush injury and acute muscle-crush compartment syndrome: with special reference to earthquake casualties. J Bone Joint Surg Br. 87(4): 450-3, 2005. Late fasciotomy risks infection and mortality.

References

13. Walters TJ, Kragh JF, Kauvar DS, Baer DG. The combined influence of hemorrhage and tourniquet application on the recovery of muscle function in rats. J Orthop Trauma. 22(1): 47-51, 2008. Risk factors are interrelated.
14. Mubarak S, Owen C. Double-Incision Fasciotomy of the Leg for Decompression in Compartment Syndromes. JBJS. 59-A, No.2, Mar 1977.
15. Odland RM, Schmidt AH. Compartment syndrome ultrafiltration catheters: report of a clinical pilot study of a novel method for managing patients at risk of compartment syndrome. J Orthop Trauma. 2011 Jun;25(6):358-65.
16. Joint Trauma System, Burn Care Clinical Practice Guideline, 11 May 2016. https://test.jts.amedd.army.mil/assets/docs/cpgs/JTS_Clinical_Practice_Guidelines_(CPGs)/Burn_Care_11_May_2016_ID12.pdf Accessed Mar 2018
17. McGill R1, Jones E, Robinson B, et al Correlation of altitude and compartment pressures in porcine hind limbs. J Surg Orthop Adv. 2011 Spring;20(1):30-3.
18. Kalns J, Cox J, Baskin J, Santos A, et al Extremity compartment syndrome in pigs during hypobaric simulation of aeromedical evacuation. Aviat Space Environ Med. 2011 Feb; 82(2):87-91.
19. Gerdin M, Wladis A, von Schreeb J. Surgical management of closed crush injury-induced compartment syndrome after earthquakes in resource-scarce settings. J Trauma Acute Care Surg. 14 Jun 2012.
20. Mathis JE, Schwartz BE, Lester JD, et al. Effect of lower extremity fasciotomy length on intracompartmental pressure in an animal model of compartment syndrome: the importance of achieving a minimum of 90% fascial release. Am J Sports Med. 2015 Jan; 43(1):75-8.
21. Bible JE, McClure DJ, Mir HR. Analysis of single-incision versus dual-incision fasciotomy for tibial fractures with acute compartment syndrome. J Orthop Trauma. 2013 Nov; 27(11):607-11.
22. Maheshwari R, Taitsman LA, Barei DP. Single-incision fasciotomy for compartmental syndrome of the leg in patients with diaphyseal tibial fractures. J Orthop Trauma. 2008; 22:723–730.
23. Kragh JF Jr1, San Antonio J, Simmons JW, et al. Compartment syndrome performance improvement project is associated with increased combat casualty survival. J Trauma Acute Care Surg. Jan 2013; 74(1):259-63.

Appendices in CPG

- **Appendix A**: Risks
- **Appendix B**: Algorithm for Clinical Decision Making on Compartment Syndrome in a Deployed Setting
- **Appendix C**: Compartment Syndrome Healthcare Record Data
- **Appendix D**: Compartment Data Sheet
- **Appendix E**: Operative Note Template
- **Appendix F**: Additional Information Regarding Off-label Uses in CPGs

Contributors

- Lt Col Gordon Wade, USAF, MC
- Lt Col Max Talbot, RCMS, CAF
- John Shero, MHA, FACHE
- CDR Charles Osier, MC, USN
- LTC Anthony Johnson, MC, USA
- CDR Luke Balsamo, MC, USN
- CAPT Zsolt Stockinger, MC, USN

Slides: Lt Col Andrew Hall, MC, USAF

Photos are part of the JTS image library unless otherwise noted.