Management of Acute Compartment Syndrome: Evidence-Based Clinical Practice Guideline

Adopted by the American Academy of Orthopaedic Surgeons (AAOS) Board of Directors
December 7, 2018
The Major Extremity Trauma and Rehabilitation Consortium in collaboration with the American Academy of Orthopaedic Surgeons
2018 Clinical Practice Guideline on the Management of Acute Compartment Syndrome

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WHAT IS A CLINICAL PRACTICE GUIDELINE?

Clinical Practice Guideline

A clinical practice guideline is a series of recommendations created to inform clinicians of best practices, based on best available evidence.
GOALS AND RATIONALE OF A CLINICAL PRACTICE GUIDELINE

- Improve treatment based on current best evidence
- Guides qualified physicians through treatment decisions to improve quality and efficiency of care
- Identify areas for future research

*CPG recommendations are not meant to be fixed protocols; patients’ needs, local resources, and clinician independent medical judgement must be considered for any specific procedure or treatment*
Evidence-Based Medicine is a combination of:

- *Individual Clinical Experience*
- *Best External Evidence*
- *Patient Values and Expectations*
Evidence-Based Medicine

Evidence-based medicine is the conscientious, explicit, and judicious use of current best evidence from clinical care research in the management of individual patients

Haynes, Sackett et al, 1996
Transferring evidence from research into practice
Sacket et al, 1996, BMJ
EBM: what it is and isn’t
IOM STANDARDS FOR DEVELOPING TRUSTWORTHY GUIDELINE

- Establish Transparency
- Management of Conflict of Interest
- Guideline Development Group Composition
- Clinical Practice Guideline-Systematic Review Intersection
- Establish Evidence of Foundations for and Rating Strength of Recommendations
- Articulation of Recommendations
- External Review
- Updating
CLINICAL PRACTICE GUIDELINE PROCESS FLOWCHART

1. Select CPG Topic

2. Assemble Work Group Members (WG)

3. WG formulates PICO questions, set inclusion criteria at Introductory Meeting

4. Literature Review and Appraisal
   AAOS staff methodologists, in conjunction with work group (WG) members, review and appraise literature

5. Final Meeting
   WG meets in-person to:
   - Review quality appraisals and evidence tables
   - Assign grade/rating for each recommendation based on evidence
   - Develop final recommendations
   - Construct risk/harms statements
   - Define future research needs

6. Review Periods
   Peer Review and Public Comment review periods

7. Approval Process

8. Communication, Dissemination, and Implementation
FORMULATING PICOs

“P” = Patient Population

“I” = Intervention or variable of Interest

“C” = Comparison

“O” = Outcome
INCLUSION/EXCLUSION CRITERIA

Standard inclusion criteria include:

- Must study humans
- Must be published in English
- Must be published in or after 1966
- Can not be performed on cadavers

Work group members define additional exclusion criteria based on PICO question
LITERATURE SEARCHES

• Databases used:
  • PubMed
  • EMBASE (Excerpta Medica database)
  • CINAHL (Cumulative Index of Nursing and Allied Health Literature)
  • Cochrane Central Register of Controlled Trials

• Search using key terms from work group’s PICO questions and inclusion criteria

• Secondary manual search of the bibliographies of all retrieved publications for relevant citations

• Recalled articles evaluated for inclusion based on the study selection criteria
BEST EVIDENCE SYNTHESIS

Include only highest quality evidence for any given outcome if available.

If there are fewer than two occurrences of an outcome of this quality, the next lowest quality is considered until at least two occurrences have been acquired.
## STRENGTH OF RECOMMENDATIONS

<table>
<thead>
<tr>
<th>STRENGTH</th>
<th>OVERALL STRENGTH OF EVIDENCE</th>
<th>STRENGTH VISUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRONG</td>
<td>Two or more HIGH Strength Studies with consistent findings</td>
<td>★★★★★</td>
</tr>
<tr>
<td>MODERATE</td>
<td>1 HIGH OR 2 MODERATE strength studies with consistent findings</td>
<td>★★★★☆</td>
</tr>
<tr>
<td>LIMITED</td>
<td>One or more LOW strength studies and/or only 1 MODERATE strength study with consistent findings or evidence from a single, or the evidence is insufficient, or conflicting</td>
<td>★★★★☆</td>
</tr>
<tr>
<td>CONSENSUS</td>
<td>Expert opinion (no studies) No supporting evidence in the absence of reliable evidence. Work group is making a recommendation based on their clinical opinion</td>
<td>★★★★☆</td>
</tr>
</tbody>
</table>
# TRANSLATING RECOMMENDATIONS IN A CPG

<table>
<thead>
<tr>
<th>STRENGTH OF RECOMMENDATION</th>
<th>PATIENT COUNSELING TIME</th>
<th>DECISION AIDS</th>
<th>IMPACT OF FUTURE RESEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong</td>
<td>Least</td>
<td>Least important, unless the evidence supports no difference between two alternative interventions</td>
<td>Not likely to change</td>
</tr>
<tr>
<td>Moderate</td>
<td>Less</td>
<td>Less important</td>
<td>Less likely to change</td>
</tr>
<tr>
<td>Limited</td>
<td>More</td>
<td>More</td>
<td>Possible / Anticipates</td>
</tr>
<tr>
<td>Consensus</td>
<td>Most</td>
<td>Most Important</td>
<td>Impact unknown</td>
</tr>
</tbody>
</table>

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ASSESSING QUALITY OF EVIDENCE

- All included studies undergo a quality assessment.
- Each study’s design is evaluated for risk of bias and receives a final quality grade, depending on the number of study design flaws.
- Study quality tables are made available to the work group in the final data report and the final publication of the guideline/SR.
RESULTS OF QUALITY ASSESSMENT: STUDY ATTRITION FLOWCHART

3607 abstracts reviewed. Primary search performed on March 6, 2018

482 articles recalled for full text review

3120 articles excluded from title and abstract review

462 articles excluded after full text review for not meeting the a priori inclusion criteria or not best evidence available

20 articles included after full text review and quality analysis
The work group is charged with:

- Review of data summaries
- Final recommendation language
- Rationale and risk/harm construction
- Future research
VOTING ON THE RECOMMENDATIONS

- Recommendations and recommendation strengths voted on by work group during final meeting
- Approved and adopted by simple majority (60%) when voting on every recommendation
- If disagreement, further discussion to whether the disagreement could be resolved
PEER REVIEW

- Guideline draft sent for peer review to external experts
- Comments and draft of responses reviewed by work group members
- Recommendation changes required a majority vote by work group
- A detailed report of all resulting revisions is published with the guideline document
PUBLIC COMMENT

Following peer review modifications, CPG undergoes public commentary period

Comments are solicited from:

AAOS Board of Directors
AAOS Council on Research and Quality
AAOS Committee on Evidence-Based Quality and Value
AAOS Board of Councilors
AAOS Board of Specialty Societies

200 commentators have the opportunity to provide input
Overview

- Based on a systematic review of published studies
- Addresses the management of acute compartment syndrome of upper or lower extremity in adults.
- This guideline addresses Acute Compartment Syndrome in all settings. However, there are many military applications to these recommendations as well.
- Highlights limitations in literature and areas requiring future research
- Trained physicians and surgeons are intended users
BIOMARKERS – MYOGLOBINURIA AND SERUM TRIPONIN

- Limited evidence supports that myoglobinuria and serum troponin level may assist in diagnosing acute compartment syndrome in patients with traumatic lower extremity injury.

Strength of Recommendation: Limited  ★★★★☆
SERUM BIOMARKERS – FEMORAL VEIN LACTATE CONCENTRATION

- Moderate evidence supports that, in patients with acute vascular ischemia, femoral vein lactate concentration sampled during surgical embolectomy may assist in the diagnosis of acute compartment syndrome.

Strength of Recommendation: Moderate ★★★☆☆
BIOMARKERS – ELECTRICAL INJURY

- Limited evidence supports that myoglobinuria does not assist in diagnosing acute compartment syndrome in patients with electrical injury.

Strength of Recommendation: Limited ★★★★☆
SERUM BIOMARKERS IN LATE/MISSED ACS

- In the absence of reliable evidence, it is the opinion of the work group that serum biomarkers do not provide useful information to guide decision making when considering fasciotomy for a presumed late-presentation or missed acute compartment syndrome.

Strength of Recommendation: Consensus 🌟🌟🌟🌟
PRESSURE METHODS - DIAGNOSIS

- Moderate evidence supports that intracompartmental pressure monitoring assists in diagnosing acute compartment syndrome.

Strength of Recommendation: Moderate  ★★★★★
PRESSURE METHODS – RULING OUT

- Moderate evidence supports the use of repeated/continuous intracompartmental pressure monitoring and a threshold of diastolic blood pressure minus intracompartmental pressure >30 mmHg to assist in ruling out acute compartment syndrome.

Strength of Recommendation: Moderate ★★★★★
PRESSURE MONITORING IN LATE/MISSED ACS

- In the absence of reliable evidence, it is the opinion of the work group that compartment pressure monitoring does not provide useful information to guide decision making when considering fasciotomy for an adult patient with evidence of irreversible intracompartmental (neuromuscular/vascular) damage.

Strength of Recommendation: Consensus

★ ★ ★ ★ ★
PHYSICAL EXAM - AWAKE

- Limited evidence supports using serial clinical exam findings to assist in ruling in acute compartment syndrome.

Strength of Recommendation: Limited ▪▪▪▪
PHYSICAL EXAM – OBTUNDED

- In the absence of reliable evidence, it is the opinion of the work group that without a dependable clinical examination (e.g. in the obtunded patient), repeated or continuous intracompartmental pressure measurements are recommended until acute compartment syndrome is diagnosed or ruled out.

Strength of Recommendation: Consensus ★★★★★
In the absence of reliable evidence, it is the opinion of the work group that there are no reported diagnostic modalities, other than direct pressure monitoring or clinical exam findings, that provide useful information to guide decision making when considering fasciotomy for acute compartment syndrome.

Strength of Recommendation: Consensus
FASCIOTOMY METHODS

- In the absence of reliable evidence, it is the opinion of the work group that fasciotomy technique (e.g. one vs two incision, placement of incisions) is less important than achieving complete decompression of the compartments of the affected extremity.

Strength of Recommendation: Consensus ★★★★★
FASCIOTOMY FOR LATE/MISSED ACS

- In the absence of reliable evidence, it is the opinion of the work group that performing fasciotomy is not indicated in an adult patient with evidence of irreversible intracompartmental (neuromuscular/vascular) damage. Fracture stabilization, if warranted in these patients, should utilize a technique (external fixation/casting) that does not violate the compartment.

Strength of Recommendation: Consensus ★★★★★
**ASSOCIATED FRACTURE**

- In the absence of reliable evidence, it is the opinion of the work group that operative fixation (external or internal) should be performed for initial stabilization of long bone fractures with concomitant acute compartment syndrome requiring fasciotomy.

**Strength of Recommendation: Consensus**
WOUND MANAGEMENT

- Limited evidence supports use of negative pressure wound therapy for management of fasciotomy wounds with regard to reducing time to wound closure and reducing the need for skin grafting.

Strength of Recommendation: Limited
PAIN MANAGEMENT EFFECTS ON DIAGNOSIS

- In the absence of reliable evidence, it is the opinion of the work group that neuraxial anesthesia may complicate the clinical diagnosis of acute compartment syndrome. If neuraxial anesthesia is administered, frequent physical examination and/or pressure monitoring should be performed.

Strength of Recommendation: Consensus ★★★★★
FUTURE RESEARCH

Consideration for future research is provided for each recommendation within this document. Review of the published literature indicates there is significant controversy regarding the accurate diagnosis of ACS. The dearth of information includes both the definition of ACS and the means to reliably and efficiently obtain objective clinical data. While fasciotomy is widely accepted as the treatment for ACS, it is also commonly done for prophylaxis (in cases of so-called “impending” compartment syndrome), and perhaps even for medicolegal reasons. Since there is no diagnostic standard for ACS, fasciotomy has become a surrogate for the diagnosis of ACS; the substitution of a treatment for a diagnosis represents a significant bias that cannot be easily controlled for in the literature. This is especially true given the strong bias that surgeons have for performing fasciotomy in order to avoid a “missed case”.
FUTURE RESEARCH

- Future research should be aimed at defining medical treatments that mitigate the pathophysiologic effects of sustained elevations in compartment pressure so that there are options other than surgical fasciotomy. An important goal would be to develop diagnostic tests that are physiologically-based and provide the clinician with information indicating whether fasciotomy must be done urgently, or whether the patient can be followed with some form of medical management initiated. Finally, methods to tell whether fasciotomy would be beneficial in the late-presenting compartment syndrome would be very significant for the proper management of such patients.
FUTURE RESEARCH – BIOMARKERS

- Future research examining the sensitivity and specificity of biomarkers compared to an appropriate reference standard (e.g. validated and/or comprehensive clinical and pressure diagnosis) in a population of patients suspected of ACS would be invaluable.
FUTURE RESEARCH – SERUM BIOMARKERS IN LATE/MISSED ACS

- While reliable diagnostic criteria for ACS may remain elusive, research should be geared towards determining serum markers that differentiate between reversible ischemia caused by ACS and indicators of neuromuscular necrosis that increases the morbidity of fasciotomy.
FUTURE RESEARCH – PRESSURE METHODS

- Further studies examining the sensitivity and specificity of pressure measuring methods, techniques and thresholds vs. reference standards that take into account false negatives and false positives would be beneficial.
FUTURE RESEARCH - PRESSURE MONITORING IN LATE/MISSED ACS

- Determining reliable compartment pressure measurements that indicate the progression to irreversible ischemia would significantly aid the clinician seeking to avoid the morbidity of fasciotomy in this population.
FUTURE RESEARCH – PHYSICAL EXAM (AWAKE)

- This question centers on the timing of post-operative mobilization exercises, defined in the 6 studies reviewed here, as the initiation of supervised physical therapy. Although easy to quantify, a physical therapy visit may not be the measure most indicative of stress on the healing repair. Absolute load and cyclic loading have been identified as factors affecting suture durability in biomechanical studies.
FUTURE RESEARCH – PHYSICAL EXAM (AWAKE)

- Further studies examining the sensitivity and specificity of pressure measuring methods, techniques and thresholds vs. reference standards that take into account false negatives and positives, as done by McQueen 2013, would be beneficial.
FUTURE RESEARCH – ALTERNATIVE METHODS OF DIAGNOSIS

- Studies examining the sensitivity and specificity of various diagnostic modalities (e.g. NIRS, Imaging, NCS, etc.) as compared to an appropriate reference standard (e.g. validated and/or comprehensive clinical and pressure diagnosis) in a population of patients suspected of ACS may have significant impact on clinicians’ ability to accurately diagnose acute compartment syndrome in a timely fashion.
FUTURE RESEARCH – FASCIOTOMY METHODS

- In the absence of reliable evidence, it is the opinion of the work group that fasciotomy technique (e.g. one vs two incision, placement of incisions) is less important than achieving complete decompression of the compartments of the affected extremity.
FUTURE RESEARCH – FASCIOTOMY FOR LATE/MISSED ACS

- In the absence of reliable evidence, it is the opinion of the work group that performing fasciotomy is not indicated in an adult patient with evidence of irreversible intracompartmental (neuromuscular/vascular) damage. Fracture stabilization, if warranted in these patients, should utilize a technique (external fixation/casting) that does not violate the compartment.
In the absence of reliable evidence, it is the opinion of the work group that operative fixation (external or internal) should be performed for initial stabilization of long bone fractures with concomitant acute compartment syndrome requiring fasciotomy.
FUTURE RESEARCH – WOUND MANAGEMENT

Future research is needed to further clarify the relative benefits associated with use of negative pressure wound therapy, with particular consideration for austere environments. This work has important implications for forward surgical teams utilized by the military. However, there may be barriers to performing this work in civilian settings due to the substantial benefits of negative pressure wound therapy in terms of patient care (fewer dressing changes, easier nursing care) as well as theoretical benefits (including reduction in nosocomial contamination due to sterile placement in the operating room, improved granulation tissue formation to improve skin graft bed). Adequately powered high quality studies are needed to explore the relationship between management of fasciotomy wounds and complication such as infection as well as rate of and time to delayed wound closure and/or skin graft. Independent variables important to study include type of wound care method (ie negative pressure wound therapy versus wet to dry guaze), use of dermatotaxis techniques (ie “Jacob’s ladder” or “shoestring” technique versus traditional), time to closure or skin graft, timing for definitive fixation/definative hardware. Both hard outcomes as well as functional outcomes and health-related quality of life outcomes are needed to adequately guide decision-making.
FUTURE RESEARCH – PAIN MANAGEMENT EFFECTS ON DIAGNOSIS

- High quality studies are needed to assess the ability to diagnose acute compartment syndrome in the setting of regional anesthesia. Similar to the obtunded patient, patients who may benefit from neuraxial anesthesia would benefit from improved monitoring for compartment syndrome. Further studies are also needed to evaluate the relationship between regional anesthesia and the development of chronic pain/chronic opioid use.
ACUTE COMPARTMENT SYNDROME CASE STUDY

The American Academy of Orthopaedic Surgeons Management of Acute Compartment Syndrome Evidence-Based Clinical Practice Guideline helps guide surgeons and other healthcare providers management of acute compartment syndrome of the upper or lower extremity in adults. The guideline summary provides the best available evidence and identifies areas with strong literature support and areas in need of future investigation.

The full case study document is available electronically at:

https://journals.lww.com/jaaos/Fulltext/2020/10010/AAOS_Clinical_Practice_Guideline__Management_of.2.aspx and was published on January 1, 2021. The case presented demonstrates how this CPG can be used in a clinical setting to help determine treatment.

Please cite these case studies as follows: Coe, Marcus P. MD, MS; Osborn, Colonel Patrick, M. MD; Schmidt, Andrew H. MD. AAOS Clinical Practice Guideline: Management of Acute Compartment Syndrome. Journal of the American Academy of Orthopaedic Surgeons: January 1, 2021-Volume 29 – Issue 1 – p e1-e4
ACUTE COMPARTMENT SYNDROME CASE STUDY

A 32-year-old man is involved in a high-speed motor vehicle accident. He was a restrained driver and was extricated from the vehicle and transferred via ambulance to a tertiary care facility. There he was found to have a painful, deformed right proximal tibia. His vital signs are stable. He is first evaluated by the trauma surgery team, who do not identify other life-threatening injuries. Radiographs reveal a Schatzker VI tibial plateau fracture (Figure 1, A and B). The treating orthopaedic surgeon is asked to evaluate the patient.
ACUTE COMPARTMENT SYNDROME CASE STUDY

- AAOS Clinical Practice Guideline: Management of Acute Compartment Syndrome
- Coe, Marcus P.; Osborn, Colonel Patrick M.; Schmidt, Andrew H.
- doi: 10.5435/JAAOS-D-19-00326
- (A and B): radiographs of the patient's initial injury in case #1.
ACUTE COMPARTMENT SYNDROME CASE STUDY

On initial evaluation, the patient is awake, alert, and conversant. He has a history of greater than 2 years of narcotic use for a back injury but has not taken opioids in over 3 months. He rates his pain as 5/10, but shifting position causes him to wince. He received intravenous pain medication in the ambulance and again on his arrival in the hospital. Examination of the right leg reveals a swollen lower leg with intact ankle dorsiflexion, toe dorsiflexion, and ankle plantar flexion. He has a palpable dorsalis pedis and posterior tibial pulse. Sensation is intact in the deep peroneal, superficial peroneal, and tibial nerve distributions. Passive stretch of his great toe causes some pain, but he is able to maintain a conversation while the orthopaedic surgeon performs the maneuver. Given the clinical examination, the orthopaedic surgeon elects to monitor the patient clinically. This is consistent with the recommendation of the ACS CPG that serial clinical examinations can assist in ruling in ACS (limited evidence).
ACUTE COMPARTMENT SYNDROME CASE STUDY

Given the unstable nature of the patient's fracture, the orthopaedic surgeon does elect to schedule the patient for urgent external fixation of his fracture with a knee-spanning construct. The orthopaedic surgeon is told that it will be a few hours before the operating room is ready because the driver of the other vehicle involved in this collision is undergoing an emergent exploratory laparotomy. The orthopaedic surgeon places the patient in a knee immobilizer and attends to other patients with plans to reevaluate the patient.
ACUTE COMPARTMENT SYNDROME CASE STUDY

Two hours later, the orthopaedic surgeon returns to see the patient. The patient is visibly uncomfortable, shifting in bed, and rating his pain as 9/10. Palpation of his lower leg compartments reveals no notable change in skin tension or fullness, but the patient has more discomfort with ankle dorsiflexion and plantar flexion. He still endorses full sensation to light touch in his foot but says it feels “weird.” The orthopaedic surgeon checks the chart and sees that over the last 2 hours, the patient has received three doses of intravenous pain medications.
ACUTE COMPARTMENT SYNDROME CASE STUDY

The orthopaedic surgeon is now concerned for compartment syndrome, but given the patient's history, he elects to check intracompartmental pressure readings, consistent with the ACS CPG's recommendation that compartment pressure monitoring can assist, but is not always necessary, in diagnosing ACS (moderate evidence). The patient's blood pressure before compartment checks is 145/70 mm Hg. The orthopaedic surgeon uses a handheld syringe-based pressure monitor and measures pressures of 30 mm Hg in the superficial posterior compartment, 35 mm Hg in the deep posterior compartment, 55 mm Hg in the anterior compartment, and 50 mm Hg in the lateral compartment. Given these findings, when combined with the increase in narcotic use and pain, the orthopaedic surgeon diagnoses him with ACS and calls the operating room to increase the urgency of his case. This diagnosis is consistent with the ACS CPG's recommendation that a difference between the patient's diastolic pressure and the intracompartmental pressure of 30 mm Hg can be used as a threshold for diagnosing ACS and performing fasciotomy (moderate evidence).
Acute Compartment Syndrome Case Study

A second anesthesia team is brought in, and the patient is in the operating room in less than an hour. The orthopaedic surgeon performs two incision, four compartment fasciotomy with care to make sure that he is visualizing and releasing all compartments while keeping in mind his plan for definitive fixation in placing these incisions. Herniating, viable, contractile muscle is found in the anterior and lateral compartments after release. The superficial and deep posterior compartments also contain viable muscle, although it does not herniate after being released. The orthopaedic surgeon then places a diamond-shaped external fixator spanning pins placed in the anterior lateral femur and anterior tibia. Treatment with fasciotomy and external fixation of the fracture are both in keeping the ACS CPG's consensus statements on treatment modalities. The skin and fascia are left open and dressed with negative pressure wound dressings in accordance with the recommendation of the ACS CPG that negative pressure wound dressings may reduce time to wound closure and the need for skin grafting (Limited Evidence).
ACUTE COMPARTMENT SYNDROME CASE STUDY

The patient is taken back to the operating room every 2 to 3 days to change his negative pressure dressings, and after 7 days, the skin overlying both fasciotomies is closed. Two and a half weeks after his initial injury, the patient undergoes open reduction and internal fixation (Figure 2, A and B).

AAOS Clinical Practice Guideline: Management of Acute Compartment Syndrome

Coe, Marcus P.; Osborn, Colonel Patrick M.; Schmidt, Andrew H.
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THIS GUIDELINE HAS BEEN ENDORSED BY THE FOLLOWING ORGANIZATIONS:

American Academy of Orthopaedic Surgeons

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes

Society of Military Orthopaedic Surgeons

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