

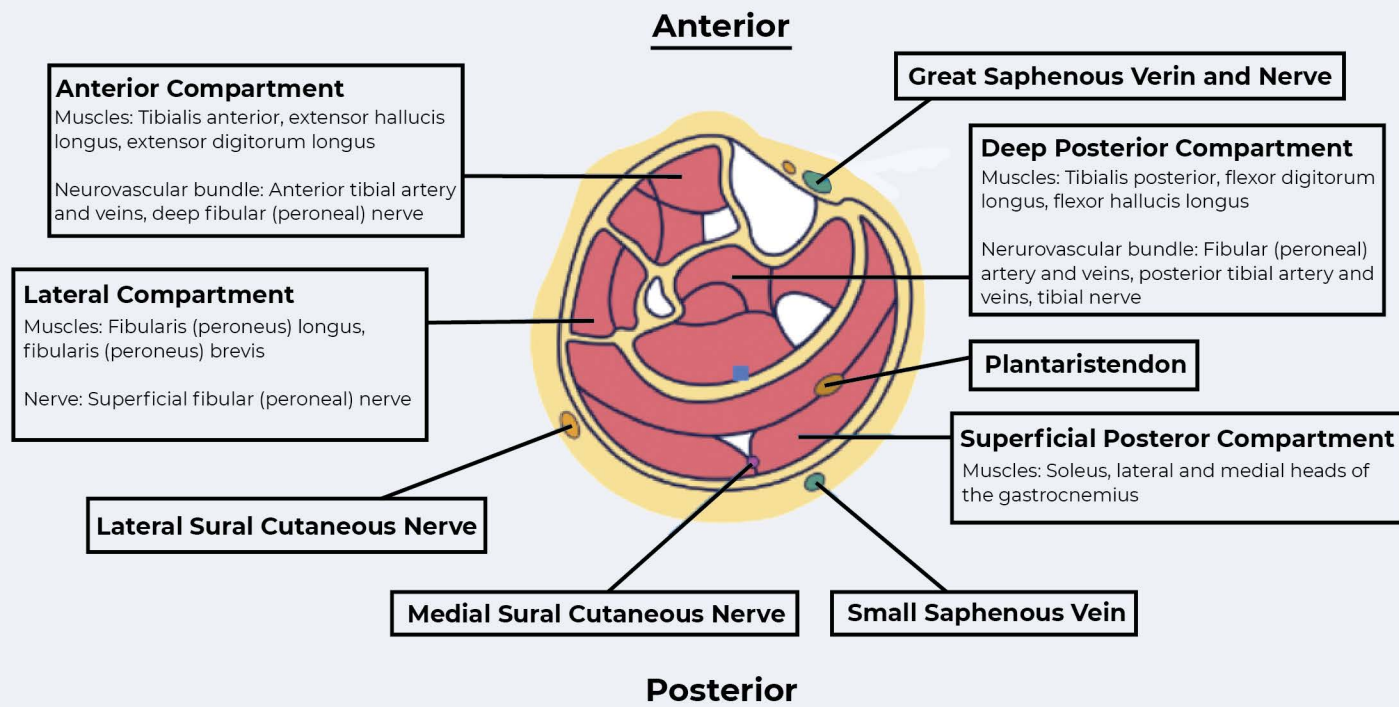
WHITE PAPER:

# Understanding Acute Compartment Syndrome: Pathophysiology, Diagnosis, and Management



**C2Dx**<sup>®</sup>

# The Challenge: Acute Compartment Syndrome (ACS) is a serious medical condition characterized by increased pressure within a muscle compartment.

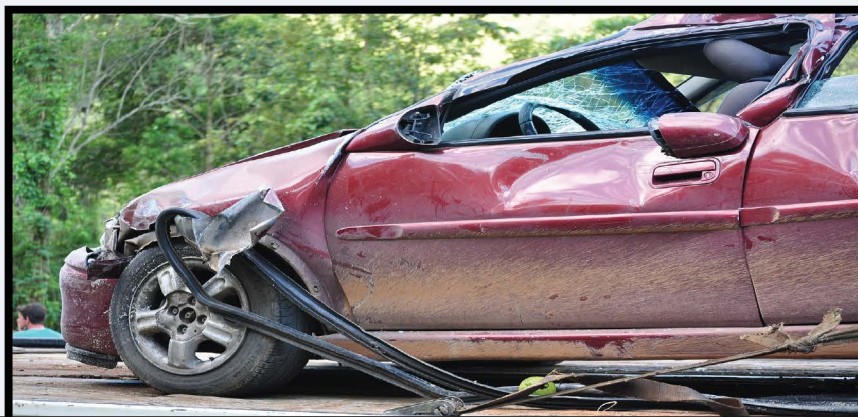


Figures 1: Cross-sectional anatomy of the left lower extremity compartments. Illustration by Renee Flick, MD.

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Commonly associated with traumatic injuries such as fractures, severe contusions, or crush injuries, ACS may not be the initial reason a patient seeks medical attention. But, if a patient's ACS is left undiagnosed, it could change the course of their life.

ACS is caused by bleeding and swelling within a muscle compartment—a collection of muscles, blood vessels, and nerves enclosed by a resilient membrane called the fascia. This swelling constricts the blood vessels, obstructing blood flow and causing ischemia (insufficient oxygen and nutrients) in the affected muscles and nerves. If not addressed promptly, ACS could result in tissue damage and possible long-term disability.<sup>1</sup>





## Symptoms of Acute Compartment Syndrome include:

- **Severe Pain:** The pain is often described as out of proportion to the injury or excessive compared to what is expected. It may be constant and worsen with movement or stretching of the affected muscles.
- **Swelling:** The effected area may appear swollen, tense, and shiny due to fluid accumulation.
- **Tightness or Fullness:** Individuals may experience a sensation of tightness or pressure in the affected compartment.
- **Numbness or Tingling:** Nerve compression can cause numbness, tingling, or a "pins and needles" sensation.
- **Weakness or Difficulty Moving:** Muscular weakness and difficulty moving the affected limb may be present.
- **Paleness or Changes in Skin Color:** In severe cases, the skin may become pale, bluish, or discolored due to reduced blood flow.<sup>2</sup>

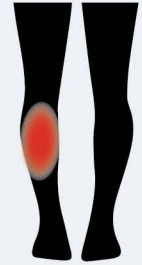
*Symptoms can vary depending on the location and severity of the compartment syndrome. If ACS is suspected, immediate medical attention should be sought to prevent further damage, ensure proper treatment, and promote optimal recovery.*



## Risk Factors:



While ACS can occur in various parts of the body, the **forearms** and **lower legs** are the most common sites affected due to the presence of multiple compartments containing muscles and nerves.



### Several risk factors can increase the likelihood of developing ACS:

- **Trauma:** Severe injuries such as fractures, crush injuries, or high-energy trauma can lead to ACS due to tissue damage, bleeding, and swelling.
- **Fractures:** Certain types of fractures, particularly those involving long bones like the tibia or forearm bones, have a higher risk of causing ACS. The fractured bone or the surrounding soft tissues can compress the muscle compartments. Tibial shaft fracture is the most common cause of ACS, and is associated with 1 to 10 percent of incidences.
- **Repetitive motion:** Activities involving repetitive motions or overuse of specific muscles, such as running or weightlifting, may increase the risk of developing chronic exertional compartment syndrome—a type of compartment syndrome that occurs during exertion.
- **Burns:** Deep burns can cause swelling and fluid accumulation, leading to increased pressure within compartments.
- **Constrictive bandages or casts:** Improperly applied tight bandages or casts can restrict blood flow and contribute to ACS development.<sup>3</sup>







**Fasciotomy:** The most common treatment for ACS is a fasciotomy, a surgical procedure where the fascia is cut to relieve the pressure and allow the muscles to expand.

During a fasciotomy, the surgeon makes one or more incisions in the fascia. By making these incisions, the surgeon allows the fascia to expand, relieving the pressure buildup within the affected muscle compartment. This helps restore normal blood flow, prevent tissue damage, and alleviate the symptoms associated with ACS, such as pain, swelling, and compromised function.

Fasciotomies can be performed on different parts of the body, depending on the affected muscle compartment. Common areas include the legs (lower leg or thigh compartments) and the arms. The specific technique and extent of the fasciotomy will depend on the severity and location of compartment syndrome.

The cost of a fasciotomy can vary depending on geographic location, medical facility, surgeon's fees, anesthesia fees, and any additional expenses associated with the procedure.

**\$10,780**

\*National Average Cost of Fasciotomy<sup>4</sup>

## Recovery Process

The recovery process following a fasciotomy can vary depending on the patient and extent of the condition. Each patient's recovery time and outcome can vary. It is essential to work closely with the health-care team.

- **Hospital Stay:** The patient is typically hospitalized to monitor their condition and ensure proper wound healing. The length of the hospital stay can vary, ranging from days to a couple of weeks.
- **Wound Care:** The surgical incisions are left open to prevent the build up of pressure within the muscle compartments. The wounds are typically covered with sterile dressings and monitored for signs of infection or complications.
- **Pain Management:** May be prescribed to alleviate post-operative pain. The healthcare team will monitor pain levels and adjust as needed.
- **Rehabilitation:** A vital part of recovery is to restore mobility, strength, and function to the affected limb. Physical therapy exercises may include gentle range-of-motion, stretching, and strengthening. Gradual progression to functional activities is typically advised.
- **Follow-Up Appointments:** The healthcare provider will assess wound healing, monitor for signs of infection or complications, evaluate functional progress, and make adjustments to the treatment plan.
- **Return to Normal Activities:** Patient health, rehabilitation plan, and extent of the initial injury will impact the timeframe. Healthcare provider will provide instructions regarding activity limitation, weight-bearing restrictions, and gradual return to activities.
- **Long-Term Care:** In some cases, patients may require long-term care and ongoing rehabilitation to manage any residual symptoms, such as muscle weakness, reduced range of motion, or nerve damage. This may involve continued physical therapy, pain management, and monitoring for potential complications.<sup>5</sup>



# Long-Term Effects of Fasciotomy

While a fasciotomy is an important and often limb-saving procedure, it is not without potential long-term effects. The risk and extent of the long-term effects are dependent on the severity of the injury, surgical site and the patient's pre-existing condition.

## Possible long-term effects:

- **Scarring:** The extent and visibility of the scar can vary depending on the surgical technique used and individual healing processes.
- **Nerve Damage:** Fasciotomy involves cutting through tissues, which can potentially damage nerves in the area. Nerve damage can lead to long-term sensory or motor deficits, such as numbness, tingling, weakness, or loss of muscle function.
- **Wound Healing Complications:** Infection, delayed wound healing, or wound breakdown can occur, which may require additional medical interventions and prolong the healing process.
- **Muscle Weakness:** The muscles that were affected by compartment syndrome and required a fasciotomy may experience long-term weakness or functional limitations. This can result from the initial injury or the surgical intervention itself.
- **Functional limitations:** Limitations may include reduced range of motion, difficulty with certain activities, or a decrease in overall physical performance.<sup>6</sup>



# Malpractice & Litigation of Fasciotomy

In the context of medical malpractice, if a healthcare professional fails to diagnose or adequately respond to ACS, resulting in harm to the patient, there may be grounds for a malpractice claim.

## Some key points to consider regarding ACS and malpractice:

- **Failure to Diagnose:** A healthcare professional's failure to recognize ACS signs and symptoms, order appropriate diagnostic tests, or refer the patient for further evaluation may be considered a breach of the standard of care.
- **Delayed Diagnosis:** A timely ACS diagnosis is crucial to prevent further damage. If a healthcare professional fails to provide a timely diagnosis of compartment syndrome despite the presence of symptoms and fails to take appropriate action, such as ordering urgent surgical intervention (fasciotomy), it could potentially be seen as negligence.<sup>8</sup>
- **Surgical Errors:** Errors during the fasciotomy surgery can lead to malpractice claims. Examples may include improper incision placement, incomplete release of the affected compartments, or damage to surrounding structures during the surgery.
- **Inadequate Monitoring:** Proper post-operative care and monitoring are crucial. Failure to adequately monitor the patient's condition, assess for potential complications, provide appropriate pain management, or take timely action if complications arise could be deemed a deviation from the standard of care.
- **Damages:** To pursue a successful malpractice claim, it is important to demonstrate that the negligence or substandard care resulted in actual harm or damages to the patient. This may include physical pain, additional medical interventions, prolonged recovery, permanent disability, loss of function, or other measurable damages.<sup>9</sup>



# An Overlooked Surgical Emergency

## ACS Case Study

**Verdict: \$111 million settlement**

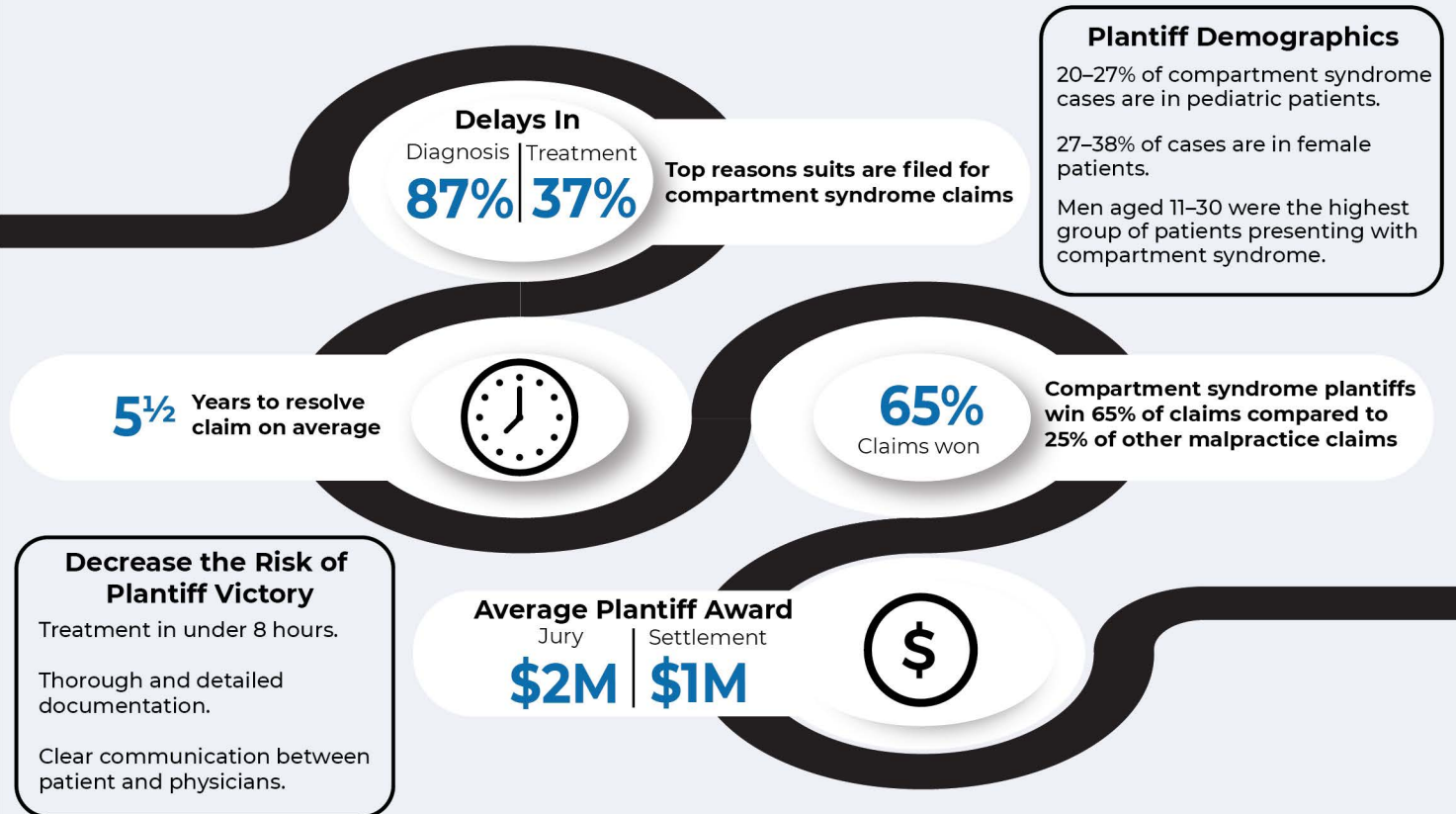
**\$1 million** in past/future medical expenses  
**\$10 million** for past pain and suffering  
**\$100 million** for future pain and suffering



A 17-year-old was injured while playing soccer. He presented to the ER with a broken left leg and underwent surgery that night. After discharge, he complained of leg pain, numbness, and burning but was sent home. **Six days later**, he returned to the hospital with extreme pain and tenderness to the leg, and was **diagnosed with ACS**. The delay in diagnosis required 12 more surgeries and resulted in permanent disabilities.<sup>10</sup>

## Malpractice, Settlements, and Jury Awards

Compartment syndrome is one of the few orthopedic emergencies and, if missed, one of the leading causes of malpractice against Orthopedic Surgeons. Testing can play a vital role in protecting the patient, the hospital and the physician.<sup>7</sup>



# Intra-Compartmental Pressure Testing

Testing with a pressure monitor, such as the STIC Pressure Monitor from C2Dx, can be a crucial step in the evaluation of ACS before a fasciotomy.

- **Objective Assessment:** An ACS diagnosis based on a clinical assessment may be inconclusive. The STIC Pressure Monitor provides an objective measurement of the pressure within the affected muscle compartment to provide quantitative data to aid in the diagnosis.
- **Guided Decision-Making:** While clinical signs and symptoms are essential, they can vary among patients. Pressure measurements provide data to help make an informed decision on course of treatment.
- **Monitoring Progression:** Pressure measurements can be taken at regular intervals or continuously. Multiple measurements help the healthcare team track changes in pressure to make timely decisions and assess the effectiveness of non-surgical interventions, such as limb elevation, ice, pain control, or decompressive measures.
- **Documentation and Legal Considerations:** Obtaining pressure measurements provides objective documentation of the condition, which can be important for medical record purposes or potential legal considerations. It demonstrates that appropriate diagnostic measures were taken and may justify surgical intervention.
- **Surgical Planning:** If a fasciotomy is required, pressure measurements can guide the surgeon during the procedure. Measurements can provide information about compartments that require decompression and the extent of the surgical intervention.
- **Research and Education:** Pressure measurements contribute to the understanding of compartment syndrome, its pathophysiology, and the effectiveness of treatment options. Researchers and healthcare professionals can also advance their practice and improve patient care.<sup>11</sup>



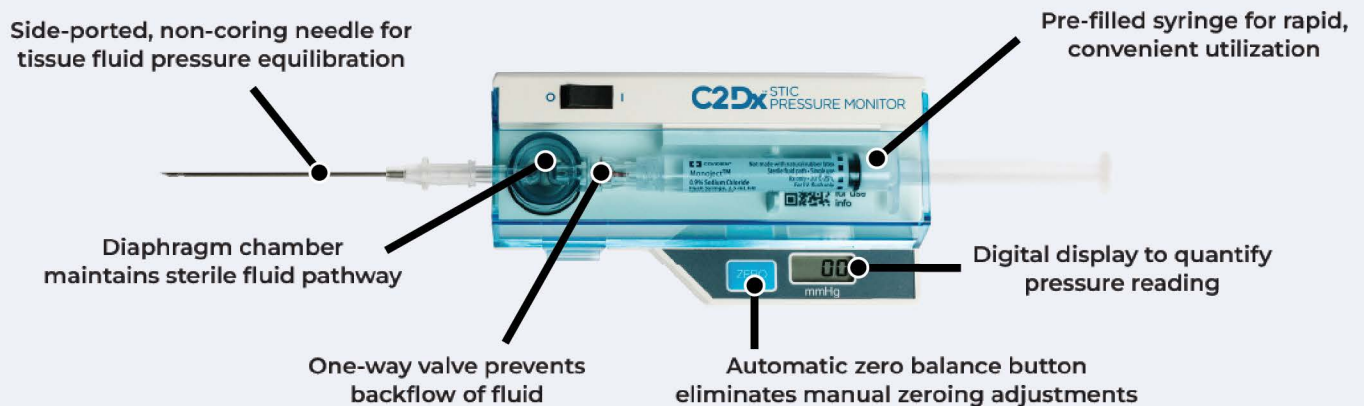
# The Trusted Solution: STIC Pressure Monitor



Reinforced by more than 30 years of clinical evidence, the STIC Intra-Compartmental Pressure Monitor is the pressure monitor you can rely on. STIC is recognized as the gold standard in intra-compartmental pressure monitoring devices. A timely and accurate diagnosis of compartment syndrome is critical to your patient outcomes.

For the most reliable readings, ensure that you have pressure monitoring equipment that's up-to-date and readily available. Pressure monitoring technology has advanced over the last 15 years, with newer models bringing added benefits.

## Key Features & Innovations



## Needle Offerings



20-Gauge Needle



18-Gauge Needle



Indwelling Slit Catheter Needle

# About C2Dx<sup>®</sup>

**C2Dx was formed in early 2019 when we acquired the STIC Intra-Compartmental Pressure Monitoring System from Stryker. We are proud to carry on the legacy of the gold standard!**



**Contact C2Dx to learn more or schedule a demonstration of The STIC Intra-Compartmental Pressure Monitoring System.**



**(888) 902-2239**



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**www.c2dx.com**



## Sources:

1. Kiel, J.; Kaiser, K. (2023). Tibial Anterior Compartment Syndrome.
2. Mabvuure, N. T., Malahias, M., Hindocha, S., Khan, W., & Juma, A. (2012). Acute Compartment Syndrome of the Limbs: Current Concepts and Management.
3. Cleveland Clinic Medical. (2021). Compartment Syndrome.
- 4.(2023). MD Save Leg Fasciotomy How Much Does a Leg Fasciotomy Cost?
5. (2023) NYU Langone. Surgery for Compartment Syndrome.
6. Yang, S., Long, Y., Wang, T., Guo, J., & Hou, Z. (2023). Predictors for surgical site infection after fasciotomy in patients with acute leg compartment syndrome.
7. Little, M. T. M., Lin, C. A., & Vrahas, M. S. (2019). Legal Aspects of Compartment Syndrome.
8. Liddell, K., Skopek, J. M., Le Gallez, I., & Fritz, Z. (2022). Differentiating Negligent Standards of Care in Diagnosis.
9. Long , B., Koyfman, A., & Gottlieb, M. (2018). Evaluation and Management of Acute Compartment Syndrome in the Emergency Department.
10. Vipul Kella, V. (2023). Compartment Syndrome: An Overlooked Surgical Emergency.
11. Jialiang, Guo & Yin, Yingchao & Jin, Lin & Zhang, Ruipeng & Hou, Zhiyong & Zhang, Yingze. (2019). Acute compartment syndrome: Cause, diagnosis, and new viewpoint.

