Factors Contributing to Delayed Diagnosis of Chronic Exertional Compartment Syndrome (CECS)

ABOUT COMPARTMENT SYNDROME

Compartment syndrome is a painful condition that occurs when pressure within the muscles builds to dangerous levels. This pressure can decrease blood flow, which prevents nourishment and oxygen from reaching nerve and muscle cells.[2] This condition can manifest in two forms: acute compartment syndrome and chronic exertional compartment syndrome (CECS). Timely diagnosis is crucial for effective management and prevention of long-term complications.

1 IN 2000

Persons / Year associated with CECS[3]

34%

of cases in a study of 150 patients with exercise induced leg pain were associated with CECS[4]

ACUTE COMPARTMENT SYNDROME

Acute compartment syndrome is a traumatic medical emergency. It is usually caused by a severe injury and is extremely painful. Acute compartment syndrome is characterized by severe symptoms that typically develop rapidly over a short period of time. If left untreated, acute compartment syndrome can lead to serious complications, such as permanent muscle or nerve damage, and even limb loss.

CHRONIC EXERTIONAL COMPARTMENT SYNDROME

Chronic exertional compartment syndrome (CECS) is an underdiagnosed condition that causes lower and upper extremity pain in certain at-risk populations. Lower-extremity CECS is most often observed in running athletes and marching military members.[1] It has been reported that 87% of patients with CECS are involved in sports, with runners accounting for 69% of cases.[9] The symptoms of CECS typically develop gradually over time and can cause significant discomfort and interfere with daily activities.

Millar, LLC. | 6001-A Gulf Freeway | Houston, TX, 77023, USA
Ph. 832-667-7000
sales@millar.com | millar.com

P/N 005-1341, Rev A

SIGNS AND SYMPTOMS OF CECS

Chronic Exertional Compartment Syndrome (CECS) is most commonly seen in athletes and military personnel who often carry large amounts of weight on their back for long periods of time or engage in high-intensity activities that involve repetitive motion of the legs or arms.[4] Additional applications can include running, jumping, cycling, weight training, skating, motorcycle use (forearm), and other activities that require repetitive use of specific muscle groups. These activities can lead to increased pressure within the muscle compartments, causing symptoms such as pain, numbness, and weakness, which can significantly affect performance and quality of life.

95%

of cases of CECS occur in the lower leg, particularly in the anterior compartment.

The anterior compartment is located at the front of the leg, and it contains muscles that are responsible for dorsiflexion of the foot and ankle.[5]

Several factors may increase the risk of developing CECS, including:

EXERCISE INTENSITY

When engaging in high-intensity activities, blood flow to the muscles increases, causing them to expand and swell. High-intensity activities such as running, jumping, or lifting weights can put increased pressure on the muscles, which can lead to CECS.[8]

EXERCISE DURATION

The pain associated with CECS typically begins gradually and increases with exercise duration. The pain usually subsides shortly after the exercise is stopped, but it may persist for several hours or even days in some cases.

ANATOMIC FACTORS

The muscles in our body are surrounded by fascial compartments, which are dense connective tissue sheaths that separate muscle groups and provide a structural framework for the muscles. In some individuals, the fascial compartments may be smaller or narrower than average, which can reduce the space available for muscle expansion during exercise.

TRAINING ERRORS

Overtraining, sudden increases in training intensity or frequency, and inadequate rest and recovery periods can increase the risk of developing CECS.[8] To avoid this condition, individuals should properly prepare and plan for physical activity, gradually increase training intensity and frequency, and allow for adequate rest and recovery periods.

DIAGNOSTIC CHALLENGES

There are various factors that can contribute to delays in identifying and diagnosing CECS, including patient-related factors, inconsistent diagnostic criteria and other diagnostic challenges. By understanding and addressing these factors, the diagnostic process for CECS can improve, leading to better patient outcomes.

PATIENT FACTORS AND OVERALL LACK OF AWARENESS

Many individuals who experience symptoms of CECS often lack awareness of the condition or underestimate the severity of their symptoms, leading to delayed medical attention as they assume that rest will resolve their issues. This tendency is particularly common among military personnel and competitive athletes who are physically fit and may push through intense pain until reaching a point where they can no longer continue. The subjective nature of pain thresholds can further complicate a CECS diagnosis, because relying solely on a traditional pain scale (1-10) can prove inadequate when compared to the more precise and informative data provided by pressure readings.

VARIABILITY IN SYMPTOM PRESENTATION

The symptoms of CECS can vary among individuals, both in terms of severity and presentation, making it challenging to recognize and diagnose the condition accurately. Patients may present with pain, swelling, or numbness, which can quickly resolve after rest.[5] This can make it difficult to differentiate CECS from other conditions, such as deep vein thrombosis, shin splints, and muscle strains.

MISDIAGNOSIS AND DIFFERENTIAL DIAGNOSIS COMPLEXITY

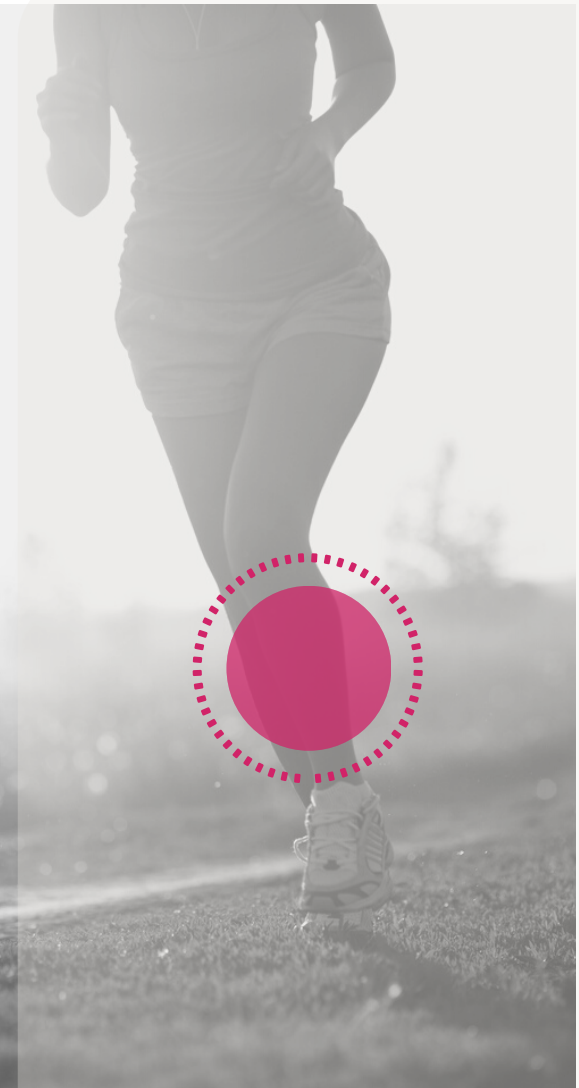
CECS can go undiagnosed with a typical delay of 22 months and is often misdiagnosed as symptoms commonly subside with rest. Differential diagnosis of CECS include medial tibial stress syndrome, stress fracture, fascial defects, nerve entrapment syndrome, popliteal artery entrapment syndrome, and claudication.[9] Misdiagnosis may result in delayed or inappropriate treatment, which can exacerbate symptoms and delay recovery.

INCONSISTENT DIAGNOSTIC CRITERIA: COMPARING ACCURACY WITH PEDOWITZ VS. ROSCOE

One challenge for physicians and patients is the lack of agreed-upon diagnostic criteria for diagnosing Chronic Exertional Compartment Syndrome (CECS). This leads to variations in diagnostic approaches among healthcare providers and potential delays in diagnosis. Two commonly referenced criteria for diagnosing compartment syndrome are the Pedowitz[7] and Roscoe[4] criterias. These rely on clinical evaluation, patient history, and measurements of intracompartmental pressures. While the Pedowitz criteria offers a straightforward, multi-insertion approach, this criteria lacks objective pressure measurements, limiting its accuracy. The Roscoe criteria provides a more comprehensive approach with continual pressure measurements but may increase diagnosis time and may not be feasible in certain settings.

PEDOWITZ DIAGNOSTIC CRITERIA

The Pedowitz criteria, established in 1990, offers a systematic approach to diagnosing compartment syndrome and relies on multiple pressure measurements, taken before and after exercise, typically with a fluid-filled measurement device. This criteria states that in the presence of appropriate clinical findings, they consider one or more of the following intramuscular pressure criteria to be diagnostic of chronic compartment syndrome of the leg: 1) a preexercise pressure greater than or equal to 15 mm Hg, 2) a 1 minute postexercise pressure of greater than or equal to 30 mm Hg, or 3) a 5 minute postexercise pressure greater than or equal to 20 mm Hg.[7] The Pedowitz criteria has been widely adopted and has guided clinical decision-making for many years. However, this approach lacks the inclusion of continual, objective measurements of intracompartmental pressure during exercise.



> **The Roscoe criteria recognizes the importance of continuous pressure monitoring during exercise, not multiple pressure measurements before and after exercise testing, which allows for more accurate assessment.**

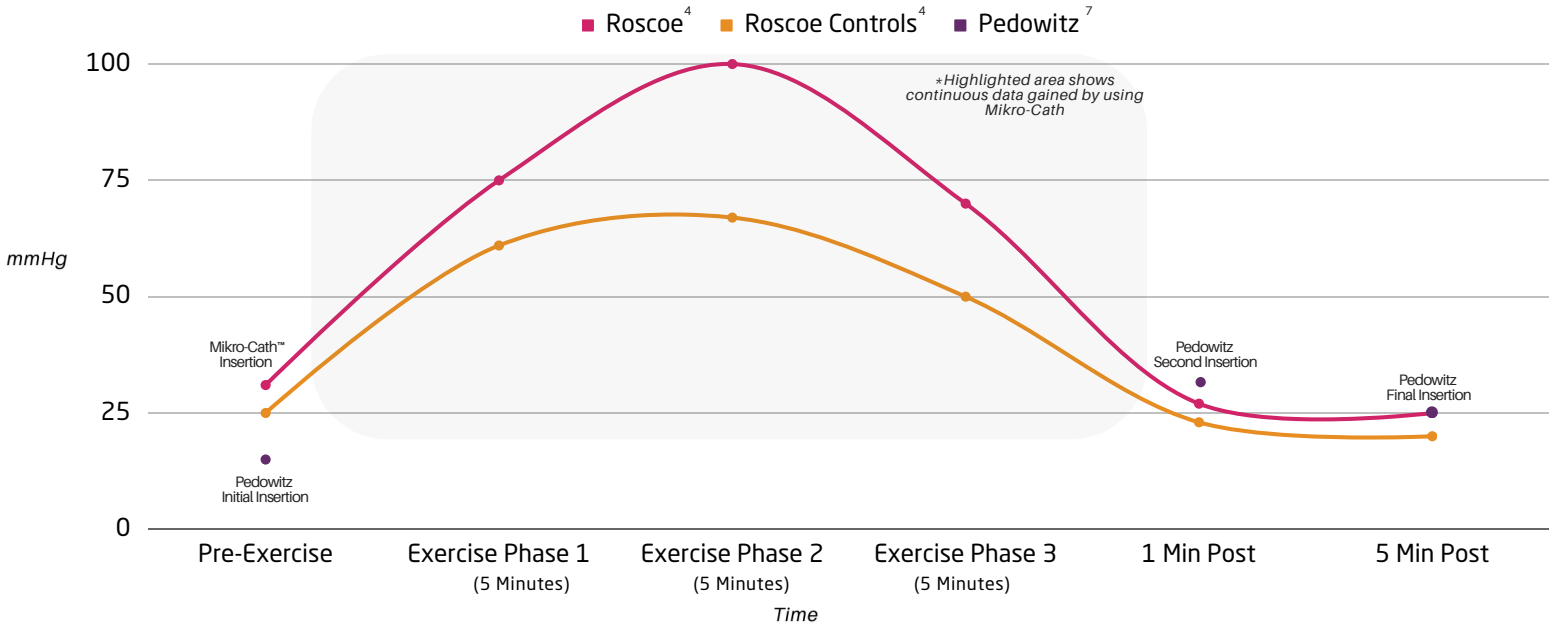
ROSCOE DIAGNOSTIC CRITERIA

The Roscoe criteria, introduced in 2015, provides an alternative approach to diagnosing compartment syndrome. This criteria recognizes the importance of continuous pressure monitoring during exercise, typically with a sold-state measurement device, versus multiple pressure measurements before and after exercise, allowing for more accurate assessment and diagnosis. According to the Roscoe criteria, in patients with symptoms consistent with CECS, diagnostic utility of intramuscular compartment pressure measurement is improved when measured continuously during exercise.[4]

In 2015, the academic Department of Military Rehabilitation at the Defense Medical Rehabilitation Centre (DMRC) proposed an updated diagnostic criteria for CECS, emphasizing the importance of continuous pressure monitoring during exercise. However, the adoption of this criteria has been slow. The modified Roscoe exercise criteria have expanded beyond the military population to include observations during exercise without a weighted pack, such as walking, running, and incline treadmill activities.[4]

Pedowitz Vs. Roscoe CECS Diagnostic Criteria

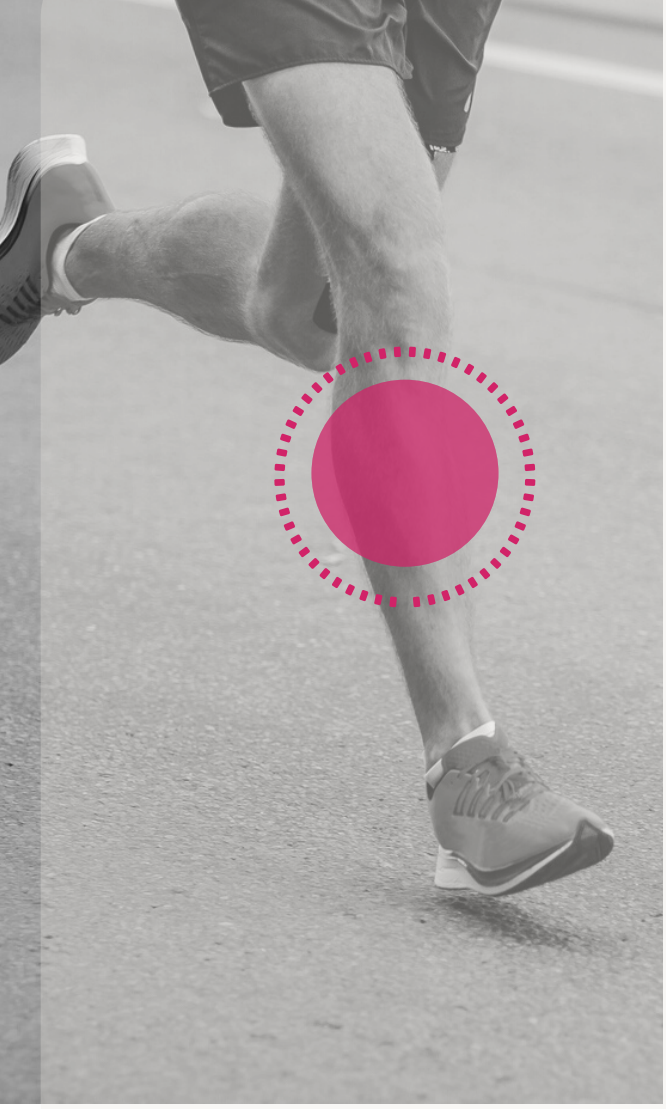
Comparison data between the Pedowitz Criteria and the Roscoe Criteria showcases pressure levels before and after exercise in contrast to continuous monitoring.



Both the Pedowitz and Roscoe criteria emphasize the importance of observing improvements in symptoms after rest. However, the Roscoe criteria recognizes the significance of pressure thresholds during exercise, which can only be accurately measured through continuous monitoring efforts. It is common for individuals to experience increased pain and pressure, accompanied by sensations of fullness, tightness, or increased girth over the anterolateral aspect of the leg during physical exercise.[4]

A reluctance to embrace change among physicians could hamper the adoption of new and advanced diagnostic methods. Outdated criteria or incorrect assumptions can lead to inaccurate or delayed diagnoses. Consequently, patients may undergo unnecessary and painful fasciotomies, resulting in both physical and financial burdens.

While transitioning to the Roscoe criteria may pose challenges, there are noteworthy advancements in compartment pressure testing offered by companies such as Millar. These advancements involve the use of clinical catheters integrated with advanced MEMS sensor technology, enabling continuous pressure measurements during exercise with minimal signal noise and artifact. These technological developments present opportunities to enhance diagnostic confidence and improve the accuracy of diagnoses.



RELIABLE CONTINUOUS MONITORING WITH THE MILLAR MIKRO-CATH ™

For over 50 years, Millar has been a leader in MEMS pressure sensor technology to develop ultraminiature sensors, as small as 170 µm or .007 in, that are placed at the end of catheters for highly accurate pressure measurements. These sensors have found clinical applications in various fields, including intracranial pressure, cardiac pressure, airway pressure, and compartment pressure monitoring.

In the context of Chronic Exertional Compartment Syndrome (CECS), Millar's Mikro-Cath™ Pressure Catheter has been clinically approved and extensively tested. It has demonstrated[4] accurate measurement of compartment pressure both during supine rest and during exercise. The sensors are well-tolerated, and their flexibility allows for continuous monitoring while walking or running on a treadmill.

A notable advantage of Millar's sensors is their placement at the catheter tip, eliminating any measurement artifacts caused by fluid and ensuring highly precise readings. The pressure collection process is straightforward, enabling efficient testing.

The use of Millar's sensors in assessing CECS represents a significant advancement in sports medicine. By providing reliable and accurate pressure measurements, these sensors assist healthcare professionals in accurately diagnosing and managing CECS in athletes and physically active individuals, ultimately improving outcomes and preventing long-term complications.

Moving away from the limitations of traditional fluid-filled needle devices, companies like Millar have developed modern catheter-based alternatives that aim to revolutionize pressure measurement procedures and enhance patient outcomes. These innovative devices streamline the process by eliminating the need for assembly, bubble flushing, and precise positioning.

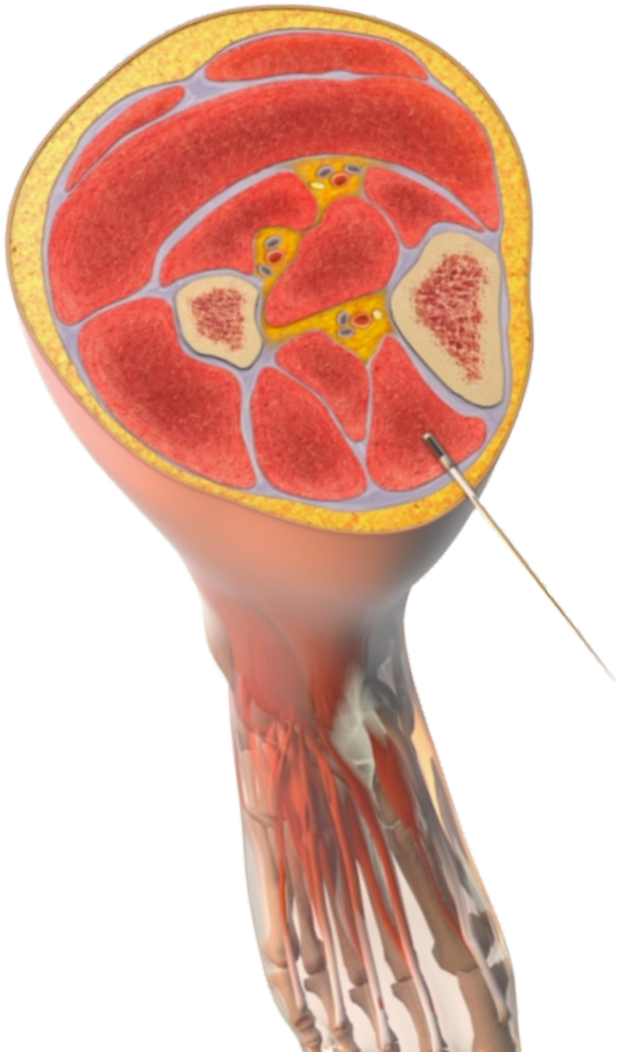
By addressing the shortcomings of previous technologies, these catheter-based devices provide physicians with more reliable pressure measurements, reducing the risk of unnecessary surgeries like fasciotomies and potential limb amputations.

MILLAR MIKRO-CATH ™

PRODUCT SPECIFICATIONS

Description	Mikro-Cath™
Model Number	825-0101
Working Length	120 cm
Tip F Size	3.5F (1.2mm)
Body F Size	2.3F (0.8mm)
Tip Configuration	Straight
Material	Nylon
Use	<24 hours
Zero Drift	<3 mmHg (0.4 kPa) in 4 hours at 25°

**Commercially produced 3.5F catheter configuration*



SOURCES

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6537460/
2. https://orthoinfo.aaos.org/en/diseases--conditions/compartment-syndrome/
3. https://emedicine.medscape.com/article/88014
4. https://pubmed.ncbi.nlm.nih.gov/25406302/
5. https://www.webmd.com/pain-management/guide/compartment-syndrome-causes-treatments
6. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3109896/
7. https://pubmed.ncbi.nlm.nih.gov/2301689/
8. https://www.mayoclinic.org/diseases-conditions/chronic-exertional-compartment-syndrome/symptoms-causes/syc-20350830
9. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5159639/

Millar.