

Isolated Chronic Exertional Compartment Syndrome of the Lateral Lower Leg

A Case Series

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Background: Exercise-induced lower leg pain may be caused by chronic exertional compartment syndrome (CECS). The anterior (ant-CECS) or deep posterior compartment (dp-CECS) is usually affected. Knowledge regarding CECS of the lateral compartment (lat-CECS) is limited.

Purpose: To describe demographic characteristics and symptoms in a consecutive series of patients with isolated CECS of the lateral compartment of the leg.

Study Design: Case series; Level of evidence, 4.

Methods: Since 2001, patients undergoing dynamic intracompartmental pressure (ICP) measurements for suspected CECS in a single institution were prospectively monitored. Individuals with a history possibly associated with lat-CECS and elevated ICP measurements (Pedowitz criteria) were identified. Exclusion criteria were concomitant ipsilateral ant-CECS/dp-CECS, acute compartment syndrome, recent significant trauma, peroneal nerve entrapment, or vascular claudication.

Results: During an 11-year time period, a total of 26 patients with isolated lat-CECS fulfilled study criteria (15 females; median age, 21 years; range, 14–48 years). Frequently identified provocative sports were running ($n = 4$), walking ($n = 4$), field hockey ($n = 3$), soccer ($n = 3$), and volleyball ($n = 2$). Exercise-induced lateral lower leg pain (92%) and tightness (42%) were often reported. The syndrome was bilateral in almost two-thirds (62%, $n = 16$). Delay in diagnosis averaged 24 months (range, 2 months to 10 years).

Conclusion: Young patients with exercise-induced pain in the lateral portions of the lower leg may suffer from isolated CECS of the lateral compartment. ICP measurements in the lateral compartment in these patients are recommended.

Keywords: chronic exertional compartment syndrome; lateral compartment; lower leg; intracompartmental pressure measurement

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Young athletes occasionally suffer from exercise-induced lower extremity symptoms caused by a chronic exertional compartment syndrome (CECS). The etiology of CECS is largely unsolved but pathologically elevated pressures in muscle compartments are consistently demonstrated.^{3,28} The diagnostic standard is provided by a dynamic intracompartmental pressure (ICP) measurement after a standard provocative treadmill test.²⁰ Current literature shows some controversy to as which compartment is most frequently affected in CECS. However, CECS of the anterior tibialis muscle (ant-CECS) or posterior flexor muscles (dp-CECS) are most frequently studied.¹¹

¹¹References 2, 4, 23, 25, 26, 32, 33, 35, 36.

High ICPs may also occur in lower leg lateral muscle compartments (lat-CECS). The limited body of literature on the incidence of lat-CECS is confusing as studies were often executed in mixed CECS populations and did not always differentiate between types of CECS.^{4,6,8,11,13,14,20,22,30} A first case of isolated lat-CECS was reported in the early 1970s.²² A recent study reported on ICP characteristics in 32 patients with lat-CECS.⁶ To date, no large studies describing demographics, risk factors, and symptomatology associated with an isolated lat-CECS were reported. Since the lateral compartment may be symptomatic in up to 35% of all CECS patients, more knowledge regarding this syndrome is desirable.⁴

Since the year 2001, patients with lower leg pain referred to our Department of Sports Medicine (Máxima Medical Center, Veldhoven, The Netherlands) for an ICP measurement are prospectively monitored. The aim of the present study was to describe demographics and baseline characteristics in a consecutive series of patients diagnosed with isolated lat-CECS. Based on clinical experience, it was hypothesized that a subset of patients may have isolated lat-CECS.

METHODS

General Study Characteristics

Our departments of sports medicine and surgery have a long-term interest in diagnosing and treating patients with exercise-related lower leg syndromes.^{7,32,35} Our institution acts as a national referral center for sports physicians and general practitioners. ICP measurements in patients suspected of CECS have been performed since 1997. Demographic and clinical data of all individuals undergoing an ICP measurement have been prospectively entered into a separate database since 2001. The first patient with a lat-CECS underwent an ICP measurement in November 2001.

Patients who presented to our department between November 2001 and December 2012 underwent history taking and physical examination. If the patient experienced exercise-induced symptoms, such as pain, in the lateral lower leg, a lat-CECS was suspected. Suspicion rose if there was tenderness of the peroneal muscles on palpation. However, a pitfall in all CECS patients is the absence of signs and symptoms at rest. Patients with a possible lat-CECS underwent ICP measurements of the affected compartments. Patients were eligible for the present study if ICP values met the Pedowitz criteria for CECS of the lateral compartment only.²⁰ Additional imaging using radiographs, magnetic resonance imaging (MRI), and bone scans were previously performed at the referring institution in a small subset of patients and excluded other pathologies such as stress fractures or medial tibial stress syndrome. Patients with an acute compartment syndrome, a history of recent trauma or lower leg surgery other than for CECS, or with vascular claudication were excluded. Between January and July 2014, patient sex, age at time of diagnosis, number of affected legs, symptoms, ICP measurements, and other electronically stored patient data were analyzed. The study was approved by our local ethical committee.

Dynamic ICP Measurement

At presentation at the outpatient department of sports medicine, patients underwent history taking and physical examination. If findings were suggestive of a lat-CECS, a dynamic ICP measurement of the lateral compartment was performed by 1 of 2 experienced sports medicine physicians (M.C., A.H.). The measurements were performed using a slit catheter (Indwelling Slit Catheter Set; Stryker) connected to an arterial line manometer and a display (pressure monitor device 783547; Hewlett Packard).^{1,16} Patients were studied in a supine position with 20° of plantar flexion of the ankle joint and 10° to 30° of flexion of the knee. Before the hollow needle containing the catheter was introduced, the overlying skin was infiltrated with 2 mL of 1% lidocaine. After needle introduction into the bulky portion of the lateral muscle compartment some 5 to 7 cm distal to the fibular head, the catheter was left in situ and the needle was removed. The catheter was connected to the manometer and patients were instructed to evert the foot against resistance to confirm correct placement.

After a resting ICP value was recorded, the catheter end was disconnected and taped onto the skin. Patients were instructed to run on a treadmill starting with a speed of 8 km/h until symptoms were maximal. Pressures were recorded immediately after cessation of exercise in the supine position and 1 and 5 minutes thereafter. Only the most symptomatic leg was measured if patients reported bilateral symptoms. If patient history and physical examination were also suggestive of ant-CECS (pain in anterior lower leg muscles, tender on palpation) or dp-CECS (deep calf muscle pain, muscle tenderness halfway up the lower leg on palpation), these compartments were also measured. Again, signs and symptoms of CECS at rest are often absent.

If an isolated lat-CECS was diagnosed based on a combined history, physical examination, and ICP values (pre-exercise pressure ≥ 15 mm Hg, 1-minute postexercise pressure ≥ 30 mm Hg, or 5-minute postexercise pressure ≥ 20 mm Hg), conservative and surgical treatment options were discussed with the patient. As the majority of patients were referred for a diagnostic ICP measurement only, results on outcomes were not available.

Statistical Analysis

Statistical analysis was performed using SPSS statistical software version 22.0 (IBM Corporation). Normality of distribution was determined using the Shapiro-Wilk test. If normal, data were expressed as mean \pm SD; if not, data were expressed as median and range.

RESULTS

Between January 2001 and December 2012, 1384 patients suspected of having CECS underwent an ICP measurement. A total of 678 of these patients demonstrated ICP measurements consistent with CECS in at least 1 compartment according to the Pedowitz criteria. Numbers of

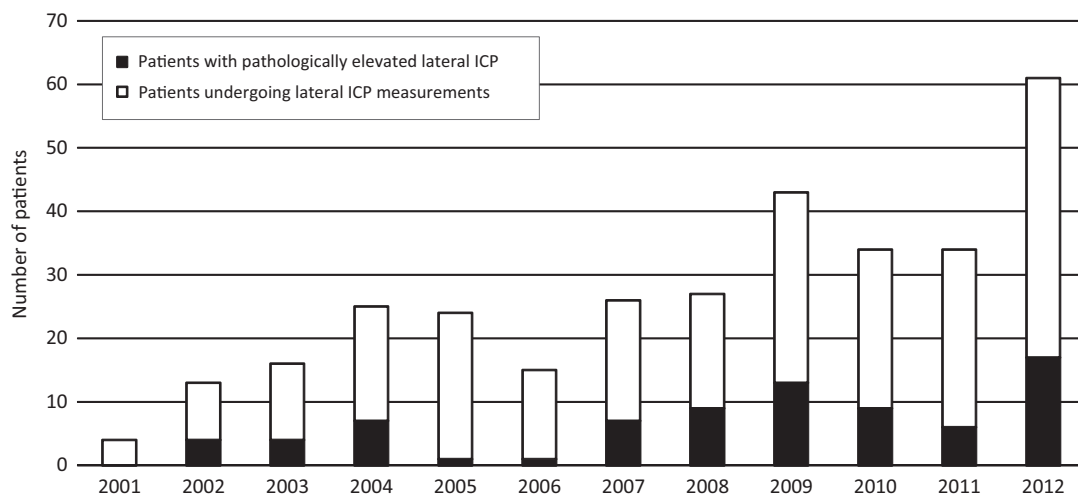


Figure 1. Number of patients with normal (gray) and elevated (black) intracompartmental pressures (ICPs) of the lateral lower leg presenting to a single institution between January 2001 and December 2012 (total number of lateral ICP measurements, n = 247; elevated ICP during rest or after provocation, n = 78).

patients potentially having a lat-CECS gradually increased during this 11-year time period (Figure 1). A total of 247 patients had signs and symptoms suggestive of lat-CECS. Moreover, 78 patients (32%) also had ICP measurements demonstrating lateral CECS. Therefore, 12% of all positive ICP measurements concerned a lat-CECS (78/678 positive compartments) (Figure 2).

Almost two-thirds (64%, 50/78) of patients with a lat-CECS had at least 1 other type of CECS. The combination ant/lat-CECS was most frequently found (42%, 33/78). Less frequent combinations were lat/ant/dp-CECS (13%, 10/78) or lat/dp-CECS (9%, 7/78). In contrast, one-third (36%, 28/78) had an isolated lat-CECS. As 2 patients were excluded for reasons listed in Figure 2, 26 patients fulfilled the current study inclusion criteria. The following data are based on this population.

A little over half of the study population (58%, 15/26) was of female sex. Symptoms started at a median age of 21 years (range, 14-48 years; unknown, n = 6). The median age at diagnosis was 27 years (range, 16-78 years). Delay in diagnosis after initial presentation to a physician averaged 24 months (range, 2 months to 10 years). Sports activities most commonly provoking symptoms of CECS were running (n = 4), walking (n = 4), field hockey (n = 3), and soccer (n = 3). Two patients did not engage in sports (Figure 3). The intensity of symptoms variously affected sports activities. For instance, 27% (4/15; unknown, n = 11) completely abstained from sports whereas 47% (7/15) were able to continue, albeit at a lower level; 13% (2/15) were able to engage in sport but with substantial additional effort.

The cardinal symptom was pain (92%, 24/26). A feeling of tightness was frequently reported (42%, 11/26). Patients also occasionally complained about cramps (19%), diminished sensibility (15%), and muscle weakness (12%). These complaints were usually reported by the patients and typically experienced at the lateral aspect of the lower leg. Examination of diminished skin sensations suggesting superficial

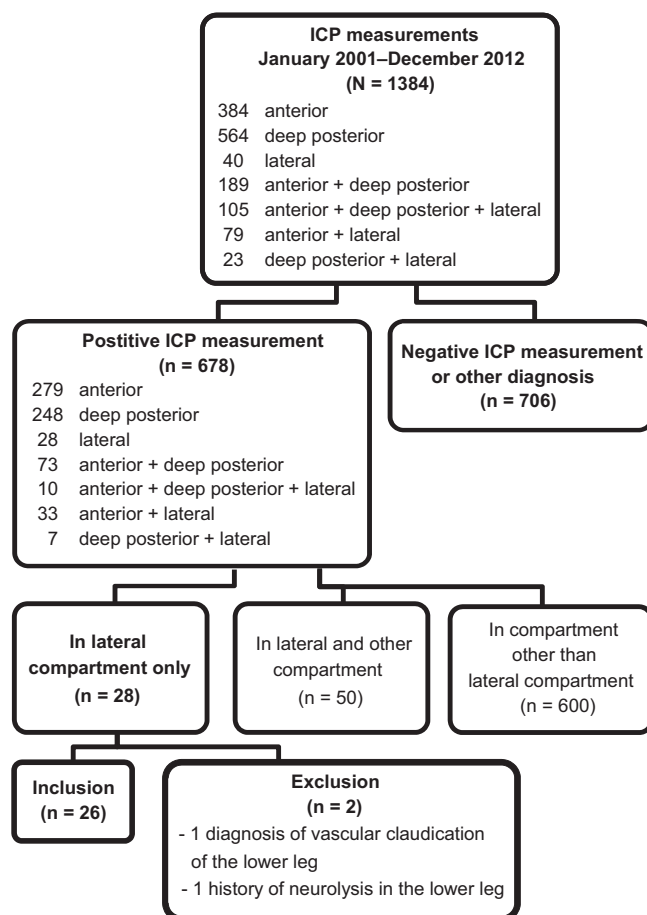


Figure 2. Flowchart of patients undergoing a dynamic intracompartmental pressure (ICP) measurement for suspected chronic exertional compartment syndrome (CECS) of any type during 11 years in a single institution.

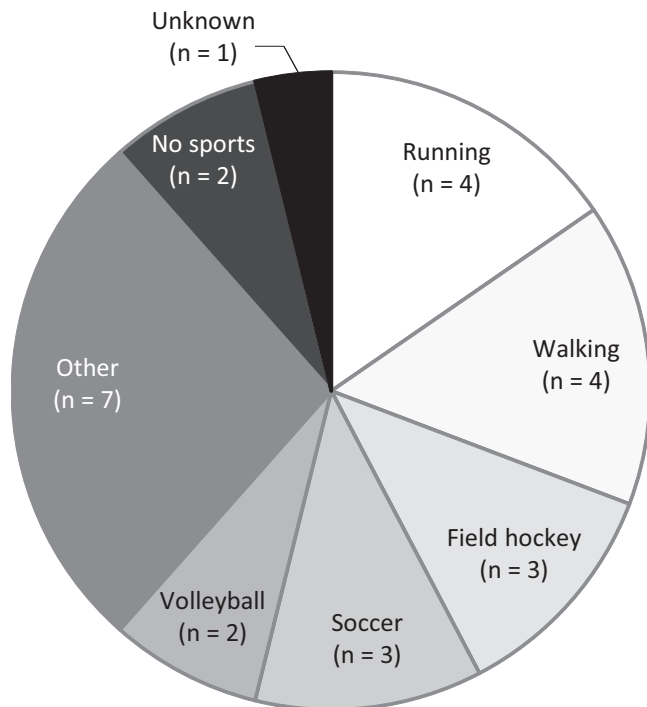


Figure 3. Sports participation by patients with an isolated lateral chronic exertional compartment syndrome of the lower leg.

peroneal nerve compression was not documented. Two-thirds (67%, 16/24; unknown, n = 2) of patients reported bilateral symptoms. The presence of lateral compartment muscle herniations was not reported. Specifics on demographics and other baseline characteristics are depicted in Table 1.

DISCUSSION

The aim of the present study was to describe demographics and baseline characteristics in the largest series to date of patients diagnosed with isolated CECS of lateral portions of the lower leg (lat-CECS). Results indicate that lat-CECS was located bilaterally in two-thirds of patients. While lat-CECS is most commonly seen in association with involvement of other compartments, one-third of patients presented with an isolated lat-CECS.

The available lower leg CECS literature is unclear regarding the most frequently affected compartment. The present study showed a predilection of anterior (58%, 395/678) or deep posterior (50%, 338/678) CECS. Lat-CECS was observed in just 12% of patients (78/678). In contrast, other studies reported that anterior and lateral compartments are frequently involved.^{6,12,19,28,30,31} Differences in incidence are probably due to patient selection or ignoring the lateral compartment as a separate compartment. For instance, some classify lower leg CECS as either anterolateral or posterior.^{5,12,28,30,31} Other authors have distinguished anterior and deep posterior from lateral compartments, and a distribution similar to ours is also reported.^{8,13,34} However,

TABLE 1
Characteristics of Patients With an Isolated Lateral Lower Leg Chronic Exertional Compartment Syndrome^a

	Isolated lat-CECS (n = 26)
Male/female, n (%)	11/15 (42/58)
Age at onset, y, median (range) (n = 20)	21 (14-48)
Age at diagnosis, y, median (range) (n = 26)	27 (16-78)
Delay in diagnosis, mo, median (range) (n = 20)	24 (2-120)
Unilateral/bilateral, n (missing)	8/16 (2)
History of earlier CECS: yes/no, n, (missing)	11/15 (0)
Symptoms reported/not reported, n (%)	
Pain	24/2 (92)
Tightness	11/15 (42)
Cramps	5/21 (19)
Loss of sensibility	4/22 (15)
Muscle weakness	3/23 (12)
ICP, mm Hg, median (range)	
Rest (n = 26)	20 (12-42)
Directly after exercise (n = 25)	38 (27-80)
1 minute (n = 22)	36 (16-71)
5 minutes (n = 22)	29 (15-60)
Level of sports activities, n (%)	
International	3 (14)
National	3 (14)
Local	4 (19)
Social	9 (43)
No	2 (10)
Unknown ^b	5
Effect on sports activities, n (%)	
Forced to stop	4 (27)
Change of sports activities	0 (0)
Sports at a lower level	7 (47)
Sports possible with complaints	2 (13)
Did not practice any sports	2 (13)
Unknown ^b	11

^aCECS, lateral lower leg chronic exertional compartment syndrome; ICP, intracompartmental pressure.

^bNot included in percentage calculation.

different incidence rates are not completely explained by neglecting the lateral compartment as a separate entity.^{6,14,20} It is highly likely that lat-CECS is underdiagnosed in general. If this were true, this phenomenon may explain some of the suboptimal results of a fasciotomy for ant-CECS (or dp-CECS). Therefore, ICP measurement of the lateral compartment is recommended in a patient who has symptoms and signs suggestive of lat-CECS, including exercise-induced pain on lateral portions of the lower leg.

The present study is the first to report on symptoms and signs in a substantial group of patients with an isolated type of lat-CECS. Pathologically elevated compartment pressures following gold-standard dynamic measurements indeed confirmed the diagnosis of isolated lat-CECS. A typical isolated lat-CECS patient is between 20 and 30 years old and consistently reports exercise-related pain on the lateral aspects of the lower leg. Occasionally, they also experience an exertional feeling of tightness, cramps, loss of skin sensation, and/or muscle weakness. Moreover, these symptoms are frequently experienced in both legs. It is

quite understandable that most sport physicians are not triggered to think of a lat-CECS in the presence of these somewhat aspecific findings. An up-to-10-year delay in diagnosis in some patients illustrates this lack of awareness. However, a steady increase in number of patients harboring an isolated lat-CECS during the 11-year study period was found. Besides the growing number of patients undergoing pressure measurements in the lower leg, an increased awareness of isolated lat-CECS as a cause of exertional lower leg pain possibly explains why isolated lat-CECS was more frequently diagnosed.

Studies of populations with various types of CECS reported that lat-CECS patients are usually healthy and active individuals who are engaged in sport activities.^{6,8,21,22,29} The present study also found that most individuals were involved in a variety of sports activities, including running, walking, field hockey, and soccer. However, sport is not conditional, as 2 of our lat-CECS patients refrained from sport activities whereas their symptoms were already evoked during normal daily activities (8%). This might be due to anatomic variations in tightness of the muscle fascia or the course of the superficial peroneal nerve.

Earlier studies suggested that lat-CECS could result in pain, tightness, muscle weakness, cramps, and loss of sensibility on lateral aspects of the lower leg.^{22,29} The present study found that pain was the only constantly reported symptom in lat-CECS. Tightness, muscle weakness, cramps, and loss of sensibility are occasionally also present on the lateral aspects of the lower leg. The impact of these symptoms on quality of life is substantial considering the finding that 6 of 26 patients competed at a national or international level (see Table 1). However, these symptoms are also characteristic of ant-CECS and dp-CECS.³⁵ Therefore, ICP measurements of a lateral lower leg compartment may be justified in each young individual with running-induced lateral lower leg pain or tightness. This is even more true when considering that most patients are often not able to make a distinction between pain in the anterior or lateral compartments.

The present study found that just 6% (78/1384) of all patients who were referred for an ICP were indeed having lat-CECS during an 11-year time period. The syndrome was bilateral in two-thirds of these lat-CECS patients. The phenomenon of bilaterality is commonly observed in mixed CECS populations (56%-88%)^{6,10,18,21,30} as well as in other lower leg types, including dp-CECS (67%) and ant-CECS (56%-61%).^{15,21} Conversely, a unilateral form of CECS is seldom found. Patients presenting with unilateral complaints may be prone to develop contralateral symptoms over time. This bilateral preponderance may have consequences for therapeutic strategies.

Muscle hernias may occur in symptomatic CECS. This phenomenon may be considered as an almost physiological response to elevated compartment pressures.^{17,20,27} In general, 10% to 60% of patients with CECS were found to harbor small fascia defects.⁵ These muscle hernias are rarely palpated, and their contribution to (or alleviation of) symptoms of CECS is unknown.⁵ Because the superficial peroneal nerve is perforating the fascia of the lateral compartment,

a higher incidence of muscle hernias in patients is hypothesized with lat-CECS. However, herniations in the area of the lateral compartment are rarely reported.¹⁷ The present study also did not diagnose herniations in lat-CECS. However, ultrasound studies were not performed. Nevertheless, physicians should be aware of these phenomena as muscle herniations probably contribute to local pain and different skin sensation. Conversely, a fasciotomy should probably incorporate these herniations.

When CECS is diagnosed, an initial conservative management including rest, physical therapy, cooling, or inlays is the treatment of choice. If this regimen fails, a fasciotomy may be advocated. Several different surgical methods have been promoted,^{8,9,24,30,37} but there is no evidence regarding the most successful procedure. The majority of patients that were evaluated in our hospital only underwent ICP measurements for confirmation of the diagnosis. Therefore, results of conservative treatment or surgeries performed in referring institutions were not available.

The present study suffers from methodological flaws due to its retrospective nature. Documentation of baseline characteristics that were retrieved from the electronic patient files was occasionally incomplete, with a risk of information bias. Follow-up studies were not performed. Results of surgery were also not obtained. These limitations have prompted us to prospectively monitor characteristics, diagnosis, and surgical treatment of all patients with lat-CECS from January 2013 onward using a standard case report form.

CONCLUSION

Chronic exertional compartment syndrome of the lateral compartment of the lower leg (lat-CECS) should be considered in young, active individuals with exercise-induced lower leg pain and/or a feeling of tightness on the lateral side of the lower leg. ICP measurements of the lateral compartment should be routinely performed in these patients.

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