

Idiopathic spontaneous bilateral leg compartment syndrome in a 43-year-old male

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BACKGROUND: Bilateral non-traumatic compartment syndrome of the legs is an exceedingly rare presentation that requires emergent surgical intervention.

CASE PRESENTATION: We report an unusual case of a 43-year-old man with acute bilateral deep posterior compartment syndrome of the legs with flexor hallucis longus myonecrosis. Despite any clear causative factor, we suggest an etiology based on the unique combination of prolonged creatine supplement use, strenuous exercise, and cocaine use.

DISCUSSION AND CONCLUSIONS: The pharmacokinetics of both creatine and cocaine might lead to increased fascial compartment pressures; furthermore, the concurrent use of each substance can potentially cause and exacerbate developing compartment syndrome. The diagnosis of compartment syndrome in the absence of traumatic causes is often delayed and leads to increased patient morbidity. A high index of suspicion and early surgical management is the key for preventing long term adverse sequelae of acute compartment syndrome.

Key Words: *Compartment syndrome; Pressure; Fasciotomy; Creatine; Lower extremity; Non-traumatic*

Acute compartment syndrome (ACS) occurs when there is a pressure increase within a confined fascial compartment that results in decreased perfusion to the tissues within the compartmental space (1). This increase in compartmental pressure leads to decreased capillary blood flow, local tissue ischemia, and tissue necrosis. The anterior and lateral compartments of the leg are the most commonly affected compartments in the lower extremity, while the superficial and deep posterior compartments are rarely involved. While the most common cause of ACS in the lower extremity is tibial fracture, there are several reported cases due to non-traumatic causes (1,2). Some reported non-traumatic causes include prolonged operative positioning, alcohol intoxication, tissue reperfusion, methanol poisoning, statin therapy, viral myositis, bleeding disorders, and diabetes mellitus (2-4). More rare reported causes of acute compartment syndrome include ruptured baker's cyst, strenuous exercise, heroin abuse, and cocaine abuse (4-6). Additionally, there have been several reported cases of compartment syndrome in athletes taking creatine supplements reported (7-9,10). Spontaneous bilateral compartment syndrome with an unknown etiology in the lower extremities is a rare presentation and can be difficult to diagnose. We report an unusual case in which the only risk factors were a combination of cocaine and creatine use as well as exercise.

CASE PRESENTATION

A 43-year-old with a history of hypertension and recurrent left leg cellulitis presented to the Emergency Department (ED) with a one-week history of left foot pain that progressed to involve his ankle and lower leg. He had been seen in our ED for cellulitis of the dorsal left foot secondary to an open insect bite twice in the previous six-month period with resolution of infection after the last encounter. The only pertinent positives in the patient's social history were cocaine use, a 23 pack-year smoking history, and use of an over-the-counter weightlifting supplement that contains creatine for the previous nine months. The patient denied any intravenous drug use. On physical examination, minimal bilateral pedal edema was noted, left greater than right, with warmth and erythema extending to the ankle. Plantar flexion and dorsiflexion were limited on the left side due to pain, but sensation was intact. The patient's body mass index was 26.18 kg/m². Vital signs at admission were pulse, 90 beats/min; respirations, 20 breaths/min; blood pressure, 147/84 mmHg; and oral temperature, 36.8°C. He remained afebrile throughout his hospital course. The anterior compartment pressure of the left leg was measured using a Stryker pressure monitor and was shown

to be 5 mmHg. His initial laboratory studies showed elevated white blood cell count of 12,100 cells/mm³, serum creatinine of 0.92 mg/dL, C-reactive protein level of 2.60 mg/dL, and creatine phosphokinase of 3,484 U/L. Serum sodium was 134 mEq/L; potassium 4.5 mEq/L; chloride, 97mEq/L; CO₂, 31 mEq/L; blood urea nitrogen, 15 mg/dL; creatinine, 0.92; glucose, 87 mEq/L. His urine toxicology screen was positive for cocaine, THC, and amphetamines. Radiographic and CT findings of the left foot showed only soft tissue swelling and edema, without evidence of atherosclerotic changes of the vasculature. Doppler ultrasound showed intact dorsalis pedis and posterior tibial arterial pulses. In the first 24 hours of admission to the hospital, the patient received multiple rounds of dilaudid and toradol, two liters of intravenous lactated ringers, and intravenous clindamycin 500 mg for suspected cellulitis. Despite these interventions, the patient continued to have pain in his left lower extremity out of proportion to exam and tense compartments of the left leg compared to the right. His creatine phosphokinase level increased to 11,640 U/L and his WBC count to 20,600 cells/mm³. Trauma and orthopedic surgery were consulted and there were differing opinions on the presence of compartment syndrome in this patient. The decision was made to take the patient to the operative room for four-compartment fasciotomy based on his continued symptoms and physical examination findings.

On opening the fascia in the posterior compartment, the flexor hallucis longus muscle appeared dusky, did not bleed when cut, and was non-reactive to electrocautery stimulation. The other muscles of the posterior compartment appeared pink and reactive. The muscles in the left anterior and lateral compartments all appeared pink and were reactive to stimulation. On postoperative day 1, the patient's right lower extremity became increasingly painful and was tense on palpation. His creatine kinase continued to trend upwards reaching 42,440 U/L. The decision was made to take the patient back to the OR for right lower extremity fasciotomy and debridement of the posterior compartment of the left lower extremity. There was no presence of compartment syndrome in the right anterior or lateral compartments. The muscles in the right posterior compartments were dusky in color, but reactive and bled when cut; therefore, no debridement was felt to be necessary at this time. The left deep posterior compartment showed myonecrosis and these tissues were subsequently debrided. On post-op day 2, the right fasciotomy was explored and revealed necrosis of the right flexor hallucis longus muscle, which was subsequently debrided. Exploration of the left fasciotomy showed frank necrosis of the flexor hallucis longus, which was debrided in its entirety,

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but bore no other new areas of ischemia. On postoperative days 3-8, the patient underwent explorations of both fasciotomy sites with debridement of any necrotic muscle tissue and partial closure of the right fasciotomy on postoperative day 5.

Internal Medicine and infectious disease were consulted to help determine the etiology of the patient's compartment syndrome. Multiple studies to identify a potential vascular, infectious, genetic, and autoimmune etiology were performed and ultimately ruled out as negative. All blood cultures and tissue cultures obtained during surgery and admission were negative. A muscle biopsy was obtained at the time of surgery showed focal areas of necrosis consistent with ischemic changes, the etiology of which could not be determined.

The patient was subsequently discharged with a portable negative pressure vacuum-assisted closure device for his left fasciotomy sites and regularly followed by wound care clinic on an outpatient basis. Six weeks following discharge from the hospital, the patient was admitted by the plastic surgery service for split-thickness skin graft for his left lower extremity fasciotomy wounds. The patient had return of baseline function to his right lower extremity at six weeks following discharge. Due to the extent of muscle debridement performed at his initial presentation, the functional deficits of the patient's left lower extremity were severe. He was ambulating with a cane, but continued to have 0/5 motor strength of the flexor hallucis longus and tibialis posterior muscles.

DISCUSSION

Non-traumatic compartment syndrome can be difficult to diagnose and can lead to delayed treatment with increased morbidity. In our patient, we could not readily identify etiology for the development of bilateral posterior compartment syndrome in his lower extremities. Rheumatologic, vascular, infectious, and autoimmune etiologies were ruled out, and the only attributable risk factors included cocaine use, prolonged creatine supplement use, and an increase in his exercise regimen.

Ischemia greater than two hours has been shown to cause damage in skeletal muscle. If it persists longer than 6 hours, muscle necrosis will begin to take place (11). The effects of cocaine on the cardiovascular system are well documented, and it exerts its effects in a number of ways. Among them, it causes increased release of catecholamines and prevents their reuptake, which increases sympathetic tone, inducing vasospasm and an increase in mean arterial pressure (12). Cocaine also stimulates production of endothelin-1 and inhibits the production of nitric oxide (12). These vascular effects of cocaine use can lead to acute arterial insufficiency and chronic limb ischemia. The pathophysiology of cocaine-induced compartment syndrome can be explained by the following mechanism. Tissue ischemia leads to cellular edema, which causes an increase in the compartmental pressure. This increase in the intracompartment pressure causes increased hydrostatic pressure at the venous end of capillary beds, which interferes with the arterial-venous pressure gradient. Flow across capillary beds is decreased and hydrostatic forces are increased, which further contributes to the tissue ischemia and edema, creating a vicious cycle (1,2,4). This cycle will continue until tissue decompression, usually in the form of compartmental fasciotomy, is performed.

Creatine, a naturally occurring high-energy phosphate carrier synthesized primarily by the liver, pancreas, and kidneys, is transported in the blood stream for storage within muscle cells (7). It provides energy for muscle contraction by donating a phosphate for adenosine triphosphate (ATP) recycling it from adenosine diphosphate (ADP) (7,8). Given the mechanism of action of naturally occurring creatine, it is thought that oral supplementation with creatine causes an increase in muscle stores to provide a higher rate of ATP recycling, increasing *de novo* protein synthesis, and an overall better performance.

Shroeder et al. 2001 reported that athletes that were given creatine in recommended doses had significantly increased anterior compartment pressures at rest and after exercise that persisted 34 days after supplementation, as compared to athletes that were not given creatine supplements (13). Creatine supplements are thought to increase muscle mass by drawing water into muscle fibers, due to its required cotransport with sodium (14). This increased water uptake leads to swelling of the muscle fiber. It has also been demonstrated that creatine supplementation causes increased *de novo* protein synthesis in skeletal muscle by an unknown mechanism (15). The rigidity of fascial compartments in the lower leg and the muscle fiber swelling due to increased water content and *de novo* protein synthesis both contribute to the increased compartmental pressures at rest and following exercise.

Additionally, there is an increase in muscle volume of up to 20% during exercise due to increased blood flow (16). The increased compartment pressure following exercise and at rest, in conjunction with the tissue volume expansion during exercise could be sufficient to cause compartment syndrome in the absence of any other likely causes.

There are a handful of case reports that link creatine supplementation with the development of lower limb compartment syndrome and rhabdomyolysis (7-10), but there has not been a large enough study conducted to substantiate a definitive and statistically significant association between creatine supplementation and the development of compartment syndrome. Of these case reports, the majority report compartment syndrome occurring in the anterior and lateral compartments of the lower extremity or gluteal compartments of the thigh (8-9,17-20). There have been no previously reported cases of bilateral posterior compartment syndrome due to strenuous exercise or creatine use. Because creatine is not regulated by the FDA, its safety profile and long-term risks are largely unknown. This must be taken into consideration when educating patients about potential risks of use of creatine supplements. Furthermore, it raises the level of suspicion that a causal relationship does in fact exist, and calls for further investigation of the long term effects of creatine supplementation.

There has been no previous exploration of the interaction between cocaine and creatine on skeletal muscle. The effects of both creatine and cocaine on skeletal muscle and its vasculature can lead to the development of compartment syndrome. The fact that our patient was using these compounds simultaneously provides an explanation as to why he presented in an unusual manner and possibly both hastened and exacerbated the subsequent compartment syndrome in both lower extremities.

CONCLUSION

In this report we described a non-traumatic spontaneous, bilateral lower extremity compartment syndrome with flexor hallucis longus myonecrosis. A definitive etiology is unknown, but we suspect a unique combination of strenuous exercise, creatine supplementation and potentially cocaine abuse led to bilateral compartment syndrome. To our knowledge this case report is particularly unique in that there was no clear inciting event that caused the patient to develop compartment syndrome. The sequence in which our patient presented, with compartment syndrome in the left deep posterior compartment followed by the right deep posterior compartment one day later, is also unusual. It serves as a pertinent example of the potential neuromuscular damage that can occur if the presentation or diagnosis of an acute compartment syndrome is delayed. A high clinical suspicion, early diagnosis, and immediate fasciotomy for compartment release is paramount to reduce morbidity and adverse long-term sequelae in these patients.

DECLARATION

Ethical Disclosure

All aspects of this study conform to the Helsinki Declaration.

Consent for publication

Written consent was not obtained for this case report, as we did not include any Protected Health Information or picture documentation specific to this patient described in the following report.

Competing interests

The authors declare that they have no competing interests

Authors' contributions

HH was a member of the treatment team for the patient described in this case and contributed to revising this manuscript critically for case accuracy and content. TF was a major contributor in writing the manuscript and literature review for the topics presented in this manuscript.

REFERENCES

1. Shadgan BS, Menon M, Sanders D, et al. Current thinking about acute compartment syndrome of the lower extremity. *Can J Surg*. 2010;53(5):329-34.
2. Elliot KGB, Johnstone AJ. Diagnosing acute compartment syndrome. *J Bone Joint Surg Br*. 2003;85(5):625-32.
3. Davidson DJ, Shaikat YM, Jenabzadeh R, et al. Spontaneous bilateral compartment syndrome in a HIV-positive patient. *BMJ Case Reports*. 2013;pp:202-651.

4. Raza H, Mahapatra A. Acute compartment syndrome in orthopedics: Causes, diagnosis, and management. *Advances In Orthopedics*. 2015;54:3412.
 5. Kuklo TR, Tis JE, Moores LK, et al. Fatal rhabdomyolysis with bilateral gluteal, thigh, and leg compartment syndrome after the army physical fitness test: a case report. *Am J Sports Medicine*. 2000;28(1):112-6.
 6. Sahni VA, Garg D, Garg S, et al. Unusual complications of heroin abuse: transverse myelitis, rhabdomyolysis, compartment syndrome, and ARF. *Clinical Toxicology*. 2008;46:153-5.
 7. Sandhu RS, Como JJ, Scalea TS. Renal failure and exercise-induced rhabdomyolysis in patients taking performance-enhancing compounds. *J Trauma*. 2002;53:761-4.
 8. Robinson, S. Acute quadriceps compartment syndrome and rhabdomyolysis in a weight lifter using high-dose creatine supplementation. *J Am Board Fam Med*. 2000;13(2):134-7.
 9. Do KD, Bellabarba C, Bhananker SM. Exertional rhabdomyolysis in a bodybuilder following overexertion: A possible link to creatine overconsumption. *Clin J Sport Med*. 2007;17:78-9.
 10. Kuklo TR, Tis JE, Moores LK, et al. Fatal rhabdomyolysis with bilateral gluteal, thigh, and leg compartment syndrome after the army physical fitness test: a case report. *Am J Sports Medicine*. 2000;28(1):112-6.
 11. Slater MS, Mullins RJ. Rhabdomyolysis and myoglobinuric renal failure in trauma and surgical patients: A review. *Journal of the American College of Surgeons*. 1998;186(6):693-716.
 12. Coughlin PA, Mavor AID. Arterial consequences of recreational drug use. *Eur J Vasc Endovasc Surg*. 2006;32:389-96.
 13. Schroeder C, Potteiger J, Randall J, et al. The effects of creatine dietary supplementation on anterior compartment pressure in the lower leg during rest and following exercise. *Clin J Sport Med*. 2001;11(2):87-95.
 14. Potteiger JA, Carper MJ, Randall JC, et al. Changes in lower leg anterior compartment pressure before, during, and after creatine supplementation. *Journal of Athletic Training*. 2002;37(2):157-163.
 15. Ingwall JS. Creatine and the control of muscle-specific protein synthesis in cardiac and skeletal muscle. *Circ Res*. 1976;38(5):115-23.
 16. Bong MR, Polatsch DB, Jazrawi LM, et al. Chronic exertional compartment syndrome: Diagnosis and management. *Bull Hosp Jt Dis*. 2005;62(3-4):77-84.
 17. Esmail AN, Flynn JM, Ganley TJ, et al. Acute exercise-induced compartment syndrome in the anterior leg: A case report. *Am J Sports Med*. 2001;29(4):509-12.
 18. Stollsteimer GT, Shelton WR. Acute atraumatic compartment syndrome in an athlete: A case report. *J of Athletic Training*. 1997;32(3):248-50.
 19. Green JE, Crowley B. Acute exertional compartment syndrome in an athlete. *Br J Plast Surg*. 2001;54(3):265-7.
 20. Ashton LA, Jarman PG, Marel E. Peroneal compartment syndrome of non-traumatic origin: A case report. *J Ortho Surg*. 2001;9(2): 67-69.
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