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Sonography

Spectral Doppler findings in a rare case of acute compartment syndrome following leg burn

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ARTICLE INFO

Article history:

Received 26 October 2017

Accepted 4 January 2018

Available online 3 February 2018

Keywords:

Compartment syndrome
Spectral Doppler

ABSTRACT

Acute compartment syndrome (ACS) is an orthopedic emergency condition, which is rarely attributed to burns. It occurs when pressure in an enclosed space rises to a point where it reduces blood flow and impairs tissue perfusion. Its consequences often lead to ischemia and possible necrosis within that space. Until now, the use of Doppler assessment to explore different types of compartment syndrome has yielded contradictory findings. Here, we present a significant increase of blood flow velocity in the arteries proximal to the burned area. Thus, the combination of Duplex ultrasound results with clinical findings will help vascular surgeons to make immediate decision to perform fasciotomy.

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Introduction

The acute compartment syndrome (ACS) is an orthopedic emergency condition, which occurs when pressure in an enclosed space rises to a point where it reduces blood flow and impairs tissue perfusion. Its consequences often lead to ischemia and possible necrosis within that space [1–3]. It is most common in the anterior and deep posterior compartments of the leg and the volar compartment of the forearm. However, it can occur anywhere in the body where an osseofascial compartment is present, including the hand, arm, foot, thigh, buttock, and abdomen [4]. The most common causes of ACS include limb trauma, arterial injury, soft tissue injury without fracture, limb compression, ischemia, poor positioning for prolonged surgical procedures, and burns [5,6]. In addition, other causes of acute

incidence of compartment syndrome include minimal trauma to the upper arm and after instrumentation or procedures such as prolonged compression from a tourniquet, arterial access devices, and venipuncture [7].

Clinical suspicion of ACS warrants a prompt surgical consultation and fasciotomy to prove limb-saving [3]. Delayed treatment can result in several complications such as nerve damage, muscle contracture, muscle weakness, and sensory changes. Thus, awareness of these complications of the syndrome may reduce delays in diagnosis [8]. The diagnosis of ACS often uses a combination of clinical signs and continuous monitoring of compartment pressure, thus allowing early diagnosis and minimization of complications [5,9,10].

To our knowledge, no previous study has investigated the use of spectral Doppler to study hemodynamics of arterial flow responses to ACS. The hypothesis that the artery proximal to

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<https://doi.org/10.1016/j.radcr.2018.01.006>

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the injured limb would reflect the intracompartment pressure modifications suggests a strong correlation between Doppler velocities and acute pressure increments in the lower limb. In this case report, we observed abnormal pulsed Doppler flow velocities in the popliteal artery and tibioperoneal trunk, proximal to a third-degree burned right leg in a patient diagnosed with ACS.

Case report

A 35-year-old previously fit and healthy man had leg burn injuries in a tribal violence. He was admitted to our medical center 2 hours after burns. The burns were located in his right leg, mainly in its anterior compartment. Upon admission, routine physical examination revealed the following: heart rate of 75 beats per minute, respiratory rate of 22 breaths/min, blood pressure of 127/90 mm Hg, and body temperature of 37.2°C. In addition, the arterial blood gas analysis of the patients' toes demonstrates arterial oxygen saturation (SaO₂) of 97%. The wounds were cleansed and dressed with silver sulfadiazine cream to avoid contamination, besides absorbing the exudates, and to keep the level of moisture adequate for healing. Resuction through the indwelling and intravenous catheters started immediately after the physical examination. An amount of 6500 mL of fluid was administrated intravenously in 24 hours. Urine output of the patient was about 2100 mL. The burns on

his right leg were of third-degree burns, which presents a positive evidence of dermal vasculature coagulation. Although these wounds were with deep partial thickness, escharotomies were not performed because there were no edema and alteration of the distal blood circulation of the affected leg.

On the following day of admission, the patient starts to complain of increasing severity of pain, extensive swelling in the right calf with altered sensation on its back compared with the other one; difficulty in walking; and numbness in the sole of his right foot. Findings on clinical examination were tense and tenderness of right calf, no neurovascular deficit, a 7-cm increase in right calf circumference compared to the left one, and positive pain noticed in ankle joint passive dorsiflexion. Spectral Doppler scans for the right limb vessels showed no evidence of deep vein thrombosis, but a significant increase of blood flow velocity in the arteries proximal to the area of the burn was noted, especially in the popliteal artery (Fig. 1) and the tibioperoneal trunk (Fig. 2) with a peak systolic velocity (PSV) of 80 and 90 cm/s, respectively. Consequently, the Stryker intracompartmental pressure (ICP) monitor (Stryker India Pvt. Ltd., Chennai, Tamil Nadu, India) confirmed the diagnosis of ACS, which revealed a compartment pressure of 65 mm Hg. Furthermore, laboratory investigation revealed an increase in creatinine kinase (CK) titer up to 2735 U/L (normal range of 38-174 U/L), whereas others such as blood urea nitrogen, calcium, potassium, sodium, sodium bicarbonate (HCO₃), glucose, chloride, and serum lactic acid were in their normal ranges.

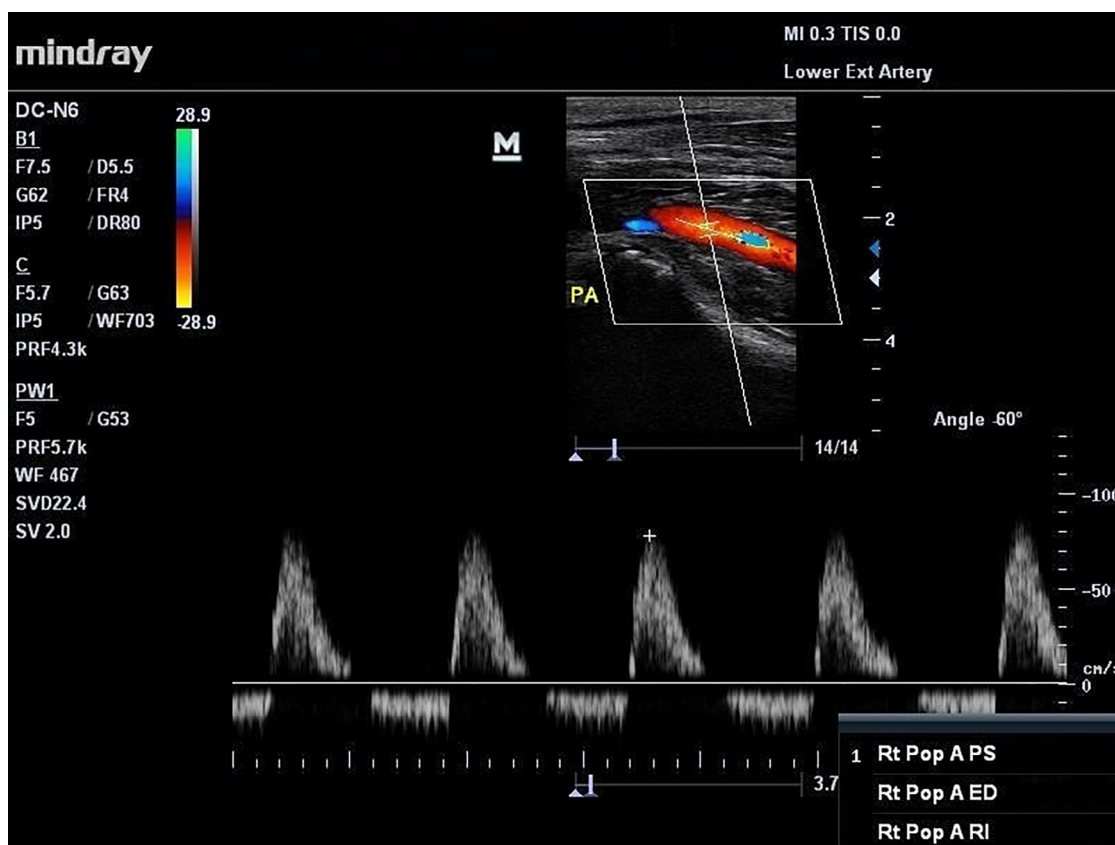


Fig. 1 – Right popliteal artery (PA) presents increased blood flow velocity (PSV = 80 cm/s) with features of spectral broadening and absence of the triphasic high-resistance waveform pattern. PSV, peak systolic velocity.

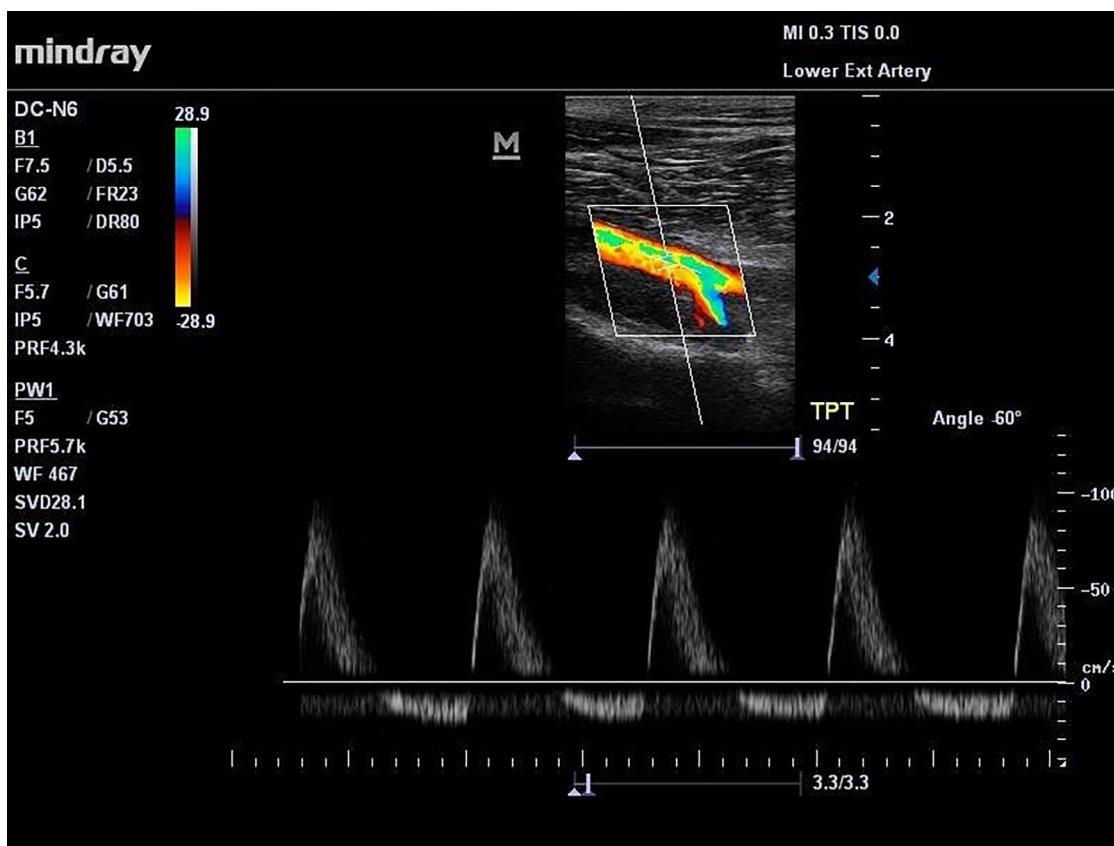


Fig. 2 – Right tibioperoneal trunk (TPT) proximal to the burned area with increased blood flow velocity (PSV = 90 cm/s) above its normal range. PSV, peak systolic velocity.

Emergent fasciotomy was performed on the right leg; minimal parts of the muscles appeared necrotic although most of the muscles were presented in dark red color. After cleaning the necrotic areas of the muscles, dressing was applied to cover the wound. On follow-up, the patient presented with promising features of wound granulation and healing, with adequate recovery, and no neurologic disabilities on the affected leg.

Discussion

ACS is a sequence of symptoms comprising lymphatic and venous drainage due to an acute circulatory defect affecting muscles and nerves in an injured area. It could lead to tissue ischemia and irreversible damage [11,12]. In 70% of cases diagnosed with ACS, the most common cause was fracture secondary to trauma. The rest of the causes include Burger disease, thrombophlebitis, and, on rare occurrence, burns [13]. Since 1969, there were only 3 cases of ACS reported in burned patients, which consequently led to the development of an ischemic necrosis in tibialis anterior muscles [14]. In 1976, 4 cases of ACS were diagnosed secondarily in burned patients [15]. From the beginning of the new millennium up to the present, ACS was seen only in 5 cases of burned patients [11]. In addition, the mechanism for the occurrence of ACS in burns could be described on the basis of the development of patchy and local

loss of capillary vessels, effects of the vascular swelling, edema in the muscle of the burned compartment, and the elasticity defect caused by scar formation after burns. Thus, the vascular defect will become severe enough to produce ACS [11].

Although the diagnosis of ACS is difficult, it can be supported by ICP measurements and elevated levels of CK [16]. ICP of muscles is normally 10 mm Hg at rest, and values ranging from 30 to 50 mm Hg have been suggested to diagnose ACS [4]. CK levels are elevated in the presence of muscle death, but there is no consensus as to what CK level constitutes significant muscle necrosis [17]. In our patient, elevated ICP and CK levels were noted. In addition, there was an increase of blood flow velocity in the popliteal artery (PSV = 80 cm/s) and tibioperoneal trunk (PSV = 90 cm/s) proximal to the area of burn during spectral Doppler examination to rule out deep vein thrombosis. To our knowledge, the normal range of PSV in the popliteal artery is 70 cm/s, and 40-50 cm/s for the tibioperoneal trunk [18].

Increasing the PSV in the arteries proximal to ACS site was supported in another study on pulsed Doppler in simulated compartment syndrome to record hemodynamic compromise [12]. These abnormal pulsed Doppler velocities were detected in the artery proximal to the injured limb that developed ACS as a result of impedance augmentation caused by the restriction of the large vessels at the fascia level as they enter and leave the affected compartment [12]. Such relation of ACS and increased PSV in the arteries proximal to the burned

area could enable a new noninvasive, economic, and widely available diagnostic approach.

Early fasciotomy of the anterior compartment has a better outcome and less complications compared with late fasciotomy [19,20]. Catastrophic outcomes were expected if fasciotomy was delayed >12 hours, whereas a full recovery would be achieved if fasciotomy was performed within 6 hours of making ACS diagnosis [21]. In our case, emergent fasciotomy was performed immediately to decompress the anterior compartment in the burned leg. Also, no complications were noticed on follow-up and adequate recovery was achieved.

Conclusion

In conclusion, although duplex ultrasound is not considered diagnostic for ACS, increased pressure in a compartment will directly increase the blood flow velocities in the proximal arteries, which can be detected and quantified using duplex Doppler sonography. Thus, the combination of the duplex ultrasound findings and the clinical presentation in this case convinced the vascular surgeons to take the patient to the operating room for a fasciotomy.

REFERENCES

- [1] Foong DP, Jose RM, Jeffery S, Titley OG. Fasciotomy: a call for proper placement. *Surgeon* 2011;9:249–54.
- [2] Ojike NI, Roberts CS, Giannoudis PV. Compartment syndrome of the thigh: a systematic review. *Injury* 2010;41:133–6.
- [3] Verwiebe EG, Kanlic EM, Saller J, Abdelgawad A. Thigh compartment syndrome, presentation and complications. *Bosn J Basic Med Sci* 2009;9:28–33.
- [4] Elliott KG, Johnstone AJ. Diagnosing acute compartment syndrome. *J Bone Joint Surg Br* 2003;85:625–32.
- [5] McQueen MM, Gaston P, Court-Brown CM. Acute compartment syndrome. Who is at risk? *J Bone Joint Surg Br* 2000;82:200–3.
- [6] Kostler W, Strohm PC, Sudkamp NP. Acute compartment syndrome of the limb. *Injury* 2005;36:992–8.
- [7] Klenerman L. The evolution of the compartment syndrome since 1948 as recorded in the JBJS. *J Bone Joint Surg Br* 2007;89:1280–2.
- [8] Hope MJ, McQueen MM. Acute compartment syndrome in the absence of fracture. *J Orthop Trauma* 2004;18:220–4.
- [9] McQueen MM. Acute compartment syndrome. In: Buchholz RW, Court-Brown CM, Heckman JD, Tornetta P 3rd, editors. *Rockwood and Green's fractures in adults*. Philadelphia: Lippincott Williams & Wilkins; 2010, p. 689–708.
- [10] Kalyani BS, Fisher BE, Roberts CS, Giannoudis PV. Compartment syndrome of the forearm: a systematic review. *J Hand Surg Am* 2011;36:535–43.
- [11] Li X, Liang D, Liu X. Compartment syndrome in burn patients. A report of five cases. *Burns* 2002;28:787–9.
- [12] McLoughlin S, McLoughlin MJ, Mateu F. Pulsed Doppler in simulated compartment syndrome: a pilot study to record hemodynamic compromise. *Ochsner J* 2013;13:500–6.
- [13] Kelsey NR, Edmonds LD, Biko DM. Acute exertional medial compartment syndrome of the foot in a teenager. *Radiol Case Rep* 2016;10:1092.
- [14] Asch MJ, Flemma RJ, Pruitt BA. Ischemic necrosis of the tibialis anterior muscle in burn patients: a report of three cases. *Surgery* 1969;66:846–9.
- [15] David L, Edward JL, Bruce GM. Tibial compartment syndromes in burn patients: a report of four cases. *Arch Surg* 1976;111:1004–8.
- [16] Lam SK, McAlister J, Oliver N, Pontell D. Bilateral medial foot compartment syndrome after an aerobic class: a case report. *J Foot Ankle Surg* 2012;51:652–5.
- [17] Ihedioha U, Sinha S, Campbell AC. Do creatinine kinase (CK) levels influence the diagnosis or outcome in patients with compartment syndrome? *Scott Med J* 2005;50:158–9.
- [18] Chavhan GB, Parra DA, Mann A, Navarro OM. Normal Doppler spectral waveforms of major pediatric vessels: specific patterns. *Radiographics* 2008;28:691–706.
- [19] Srikanth KN, Chong M, Porter K. Acute exertional compartment syndrome of the superficial posterior compartment of the leg. *Acta Orthop Belg* 2006;72:507–10.
- [20] Ebraheim NA, Abdelgawad AA, Ebraheim MA, Alla SR. Bedside fasciotomy under local anesthesia for acute compartment syndrome: a feasible and reliable procedure in selected cases. *J Orthop Traumatol* 2012;13:153–7.
- [21] Fowler SJ, Symons J, Sabato S, Myles PS. Epidural analgesia compared with peripheral nerve blockade after major knee surgery: a systematic review and meta-analysis of randomized trials. *Br J Anaesth* 2008;100:154–64.