

CASE REPORT

Delayed Presentation of a Compartment Syndrome of the Foot: A Case Report in a Young Patient

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Foot compartment syndrome is a serious potential complication of foot crush injury, fractures, surgery, and vascular injury. In this article, we report the case of a delayed presentation of a compartment syndrome of the foot. The young patient, a male student of 13 years old, reported several fractures of the tarsal and metatarsal bones of the left foot after a crush injury. Except from intense pain, no other P sign was present in the first 6 hours from the accident. Approximately 24 hours after the injury, the patient was admitted in the operating room. A double incision fasciotomy for access to forefoot compartments was performed. The osteosynthesis of the fractures was performed only 13 days later. At one year of follow-up, the young patient did not present any neuromuscular disorder and returned to his normal activities.

Vigilance is warranted in evaluating the compartments of patients with extremity injuries, as every delay in diagnosis and treatment correlates with poor outcome. Physicians should be aware of the possibility of compartment syndrome of the foot emerging irrespective of the severity of the initial trauma.

Keywords: case report; compartment syndrome; crush injury; fasciotomy; intra-compartment pressure

Introduction

Acute compartment syndrome (ACS) is defined by a critical pressure increase within a confined compartmental space, causing a decline in the perfusion pressure to the compartment tissue [1, 2]. Without timely diagnosis and treatment will lead to ischemia, necrosis and ultimately permanent disability of the affected region [1–3]. Compartment syndromes can arise in any area of the body that has little or no capacity for tissue expansion, such as the abdomen, buttocks and hands [4]. Compartment syndrome in the foot occurs when there is an elevation in compartment pressure in any of the nine osteofascial compartments of the foot [5, 6]. The sequelae of inadequately managed foot compartment syndrome are poorly tolerated and often necessitate multiple procedures for rehabilitation, ranging from physical therapy with corrective bracing to limb amputation [5, 7, 8]. Adverse patient outcomes due to delayed or missed diagnosis also have significant medico-legal ramifications for surgeons [4]. For these reasons, it is essential for the orthopedic surgeon to know the various conditions that can lead to a compart-

ment syndrome of the foot and to be able to recognize the symptoms in order to make an early diagnosis and treatment.

We present a case of a delayed presentation of compartment syndrome of the foot after crush injury in a young patient, in which diagnosis and treatment were made only 24 hours after trauma. Fortunately, apart from the cosmetic problem and feeble paresthesia, no severe vascular and neuromuscular sequelae developed and the young patient could return to all his daily activities. This work has been reported in line with the SCARE criteria [9].

Case presentation

A male student of 13 years old with no prior history of lower limb trauma or medical illnesses and with a normal stature arrived at our emergency room with a crush injury of the left foot 3 hours after being run over by a car. At the arrival, the left foot was remarkably swollen with intense pain and functional impotence. The X-rays showed fractures of the head of II, III, IV e V metatarsal bones, fracture of the diaphysis of the II metatarsal bone, fractures of the base of V metatarsal bone and plurifragmentaries fractures of the cuboid and navicular bones (**Figure 1**). A CT of the foot was immediately required. The CT images confirmed those fractures and revealed also a partial detachment of anterior part of the talus, the calcaneus and of II and III cuneiform bones and partial detachment of the base of proximal phalanx of the toe (**Figure 1**). The patient was hospitalized and observed in the following hours. An antalgic therapy with tramadol and paraceta-

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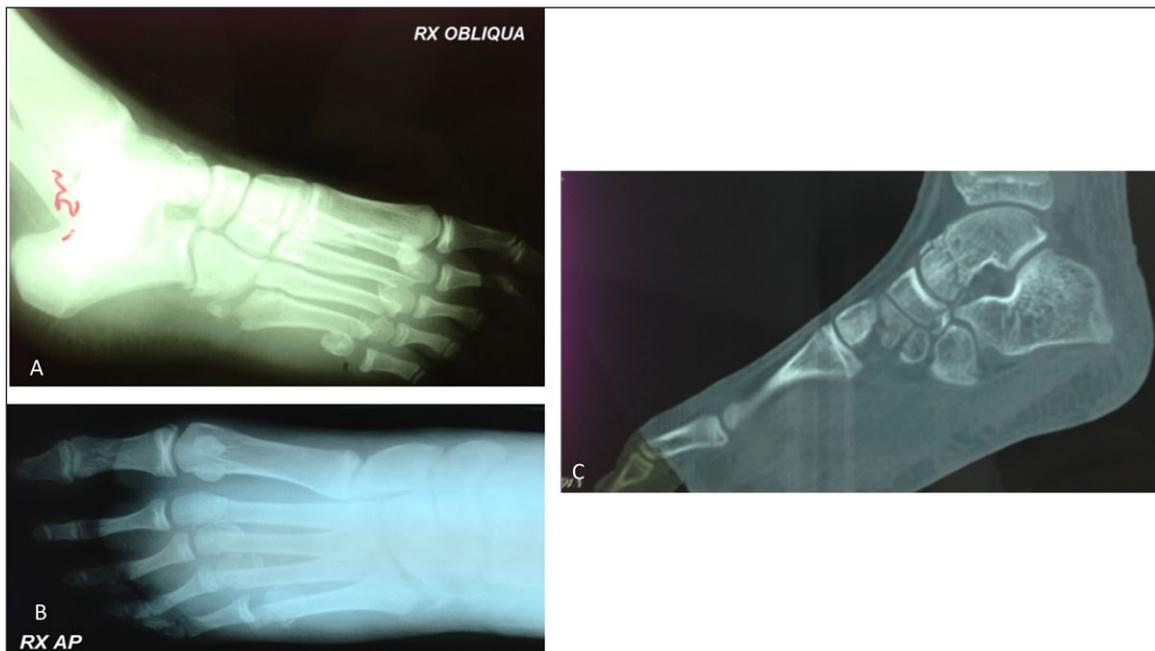


Figure 1: The X-rays (A, B) showed fractures of the head of II, III, IV e V metatarsal bones, fracture of the diaphysis of the II metatarsal bone, fractures of the base of V metatarsal bone and plurifragmentaries fractures of the cuboid and navicular bones. The CT images (C) confirmed those fractures and revealed parcellar detachment of anterior part of the talus, the calcaneus and the II and III cuneiform bones and parcellar detachment of the base of proximal phalanx of the toe.



Figure 2: 6 hours after the trauma, the ankle and the foot were considerably swollen with substantial subcutaneous hematoma, perimalleolar edema and blisters on the medial and lateral side.

mol, an antithromboembolic and a broad spectrum antibiotic prophylaxis were immediately set up. At 6 hours from the trauma, the ankle and the foot remained considerably swollen with substantial subcutaneous hematoma, perimalleolar edema and blisters on the medial and lateral side (Figure 2). The intensity of pain was 7/10 and it was not modified by the passive stretching of the ankle in dorsiflexion. The neurological examination was negative with no paresthesia and signs of paralysis. Doppler ultrasound

revealed regular pulses for the anterior and posterior tibial artery, for the dorsalis pedis artery and all the interdigital arteries; no vascular emergency was indicated, but only clinical observation. The kidney function was normal with a normal range of values of creatinine and CPK. The intracompartment pressure of the foot was not measurable because our institute is not equipped with devices for the measurement. Considering all these parameters, no emergency indication was made and the treatment choice

was only clinical observation with control of the pain and eventual rising of neurovascular disorders.

24 hours after trauma the patient continued to wail for pain, becoming upset and less compliant. Despite the antalgic therapy, the intensity of pain increased to 9/10 and it was enhanced by the passive dorsiflexion of the ankle. The foot remained swollen with consistent edema of the soft tissue, while the skin became tender and pink. Neurological examination revealed paresthesia of the dorsum of the foot, the II and III digits and one-inch inferior to medial malleolus with initial paralysis of the extensor hallucis brevis and of the extensor digitorum brevis. Peripheral pulses were still present and a new Doppler ultrasound was performed showing normal perfusion. ICP was not measurable. Considering all these parameters, the orthopedic surgeon made a diagnosis of incoming compartment syndrome of the foot. The patient was immediately admitted in the operating theatre. The surgical procedure was performed by an expert trauma surgeon (BM) A double dorsal incision fasciotomy over the second to the fourth metatarsal was performed with decompression of the forefoot compartments (**Figure 3a**). A third incision, medial or lateral, was unnecessary (**Figure 3b**). After the operation, the patient was strictly observed. In the immediate postoperative period pain, swelling and paresthesia gradually reduced while motility of the foot and of the ankle slightly improved. The wounds were daily treated with a pomade of collagenase and protease and covered by bandages of phytostimulines. After 13 days from fasciotomy, the young patient was again admitted

in the operating room for debridement of the wounds made by a plastic surgeon (GG) (**Figure 4a**). The osteosynthesis of the III, IV and V metatarsal bones with k-wires was made by an orthopedic surgeon VP (Vito Pesce) (**Figure 4b, c**). In the second postoperative period closure of the wounds was managed with ten days of negative pressure wound therapy (NPWT) followed by tissue coverage with an autologous skin graft. On day 40, examination only revealed the presence of persistent feeble paresthesia of dorsum of the foot and cosmetic problem due to skin grafting. The motility of the digits, the foot and the ankle was wholly restored without signs of muscular retraction; there wasn't any problem of infection and skin necrosis. At one year of follow-up, the patient still complained only for the cosmetic problem and feeble paresthesia of dorsum of the foot (**Figure 5a, b**). The patient was subjectively satisfied with function, had no limitations in her activities of daily life and needed no analgesics. Radiologically, a consolidated fracture was seen without any signs of metatarsals head necrosis. The AOFAS score was 88 points on the left and 98 points on the right.

Discussion

Foot compartment syndrome is a severe clinical entity that typically results from high-energy fractures and crush injuries [10]. The incidence of compartment syndrome of the foot is around 6% in road accident according to the literature [11, 12]. The diagnosis is challenging and requires a high index of suspicion. It is based on clinical examination and measurement of the intracom-



Figure 3: A double dorsal incision fasciotomy over the second to the fourth metatarsal was performed with decompression of the forefoot compartments (**A**). A third incision, medial or lateral, was unnecessary (**B**).



Figure 4: 13 days after the fasciotomy procedure, the young patient was again admitted in the operating room for debridement of the wounds (**A**) and osteosynthesis of the III, IV and V metatarsal bones with k-wires (**B, C**).



Figure 5: At one year of follow-up the patient still complained only for cosmetic problem due to skin grafting.

partmental pressure. The typical clinical presentation of compartment syndrome of the foot is not different from other affected body regions [11]. In a systematic review, the pain was identified as the earliest and most sensitive clinical sign of a manifest compartment syndrome of the foot [13]. Pain with passive stretch had comparable sensitivity, specificity, and predictive values [13]. Muscle strength is not a useful parameter since it is difficult to judge in a patient with injuries and is dependent on the pain that may be due to those injuries. Examination of pulses is unreliable in the diagnosis of compartment syndrome since intracompartmental pressure does not reach systolic blood pressure [11]. Sensory deficits, especially paresthesia, are also common in patients with compartment syndrome [2, 3, 13]. It is important to underline that all these symptoms have low sensitivity (13%–19%) and high specificity (97%–98%); so they are better at excluding than confirming a diagnosis [13]. For this reason, it is necessary to measure the intracompartmental pressure for a definite diagnosis. Tissue pressures more than 30 mm Hg or within 10–30 mm Hg could be an absolute indication for fasciotomy [2, 5, 14]. In our case, ICP was not measurable. Probably this leads to a delay in diagnosis in the first hours when the symptoms were questionable. However, once the diagnosis was made, acute compartment syndrome of the foot is treated as an orthopedic surgical emergency [15]. The earlier a manifest compartment is released the less likely that long-term sequelae will develop [11]. McQueen et al. demonstrated that the time between apparent onset of compartment syndrome and surgical release influenced the outcome rather than the time between trauma and fracture stabilization [16–18]. The surgical decompression is obtained by fasciotomy; the number and the type of incisions depend on the affected compartments. In the foot were described nine different compartments: four interosseous, one of adductor hallucis, one medial, one lateral and two central (one deep/calcanal and one superficial). The two dorsal incisions over the second to fourth metatarsals is used for decompressing the forefoot compartments (interosseous and adductor hallucis). A medial incision can be used to decompress the calcaneal, medial and superficial compartments. The lateral incision, beginning at the lateral malleolus extending to the forefoot between the fourth and fifth metatarsals can be used to decompress

the lateral compartment [4, 6, 11, 14]. In our case, we performed only the double dorsal incision fasciotomy for decompressing the forefoot compartments. A third incision, medial or lateral, was unnecessary.

Although there is no consensus regarding the optimum timing of wound closure [19], primary closure of the wound is not commonly performed [20]. Delaying closure for about seven days allows wound edges approximation at closure [4, 21]. Moreover, there may be the need for repeat irrigation and debridement before final wound closure. There may be a role for various adjuncts and techniques developed to increase the rate of skin closure such as vacuum-assisted closure [19, 22] and skin grafting [23, 24]. In our case, we have chosen for a secondary closure of the wounds after fasciotomy followed by a new debridement, by ten days of vacuum-assisted therapy and finally by skin grafting.

According to literature, foot compartment syndrome can lead to severe sequelae affecting patient autonomy. Ischemic muscle fibrosis and retraction result in foot and ankle deformities ranging from claw toes to complex multiplanar dislocations with soft tissue impairment [25]. The sequelae of inadequately managed foot compartment syndrome are poorly tolerated and often necessitate multiple procedures for rehabilitation, ranging from physical therapy with corrective bracing to limb amputation [5, 7, 8]. Although the delayed treatment after 24 hours from trauma, our patient did not present any neuromuscular disorder in the post-operative period; any secondary surgery was required. Therefore, the young student could return to all his daily activities without problems.

Conclusion

Foot compartment syndrome is a serious potential complication of foot crush injury, fractures, surgery, and vascular injury. When not treated promptly, compartment syndrome can lead to disastrous complications including muscle necrosis, Volkmann's contracture, neurological deficit, crush syndrome, and even death. The diagnosis is challenging and requires a high index of suspicion. It is based on clinical examination and measurement of the intracompartmental pressure. This case represents a delayed and incomplete presentation of ACS of the foot in which diagnosis was made without ICP measurement. Although the treatment was performed only 24 hours

from trauma, the patient, fortunately, did not develop any severe vascular and neuromuscular disorders. Therefore, considering the low sensitivity of the symptoms of ACS and the necessity to avoid a delayed treatment for the eventual devastating long-term sequelae, this case highlights the possibility to consider the fasciotomy in doubtful cases in which ICP is not measurable. Physicians should be aware of the possibility of compartment syndrome of the foot emerging irrespective of the severity of the initial trauma. As Helfet et al. stated: “if you think to do a fasciotomy, maybe you should do one” [26, 27].

Ethics and Consent

Informed consent was obtained from the patient for the publication.

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Competing Interests

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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