Trauma Case Reports 46 (2023) 100852

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Case Report

Refractory compartment syndrome after antivenom administration for an Eastern Diamondback Rattlesnake bite requiring fasciotomy for limb salvage: A case report☆

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ARTICLE INFO

Keywords:
Snake bite
Compartment syndrome
Fasciotomy
Envenomation
Rattlesnake
Antivenom

ABSTRACT

Case: 56-year-old male who developed post-snakebite compartment syndrome (PSCS) of the upper extremity which was refractory to antivenom administration. He had elevated compartment pressure measurements in his upper extremity. He underwent open fasciotomy for the compartment syndrome, followed by delayed primary closure and skin grafting. He now has two years of follow-up with a functional upper extremity.

Conclusion: This is a case of a patient who suffered post-snakebite compartment syndrome from his pet Eastern Diamondback Rattlesnake. This case highlights the importance of correctly diagnosing compartment syndrome and validates fasciotomy as a treatment measure for confirmed post-snakebite compartment syndrome (PSCS).

Introduction

Compartment syndrome is the increase of intercompartmental pressure within a closed interfacial compartment, often following fracture, soft tissue injury, or vascular injury. Patients may present with the five Ps: pain, pallor, pulselessness, paralysis, and paresthesia. Compartment syndrome is a surgical emergency, and can result in necrosis, rhabdomyolysis, or paralysis if fasciotomy is not performed in a timely manner [1]. If any of the measured compartment pressures are within 30 mmHg of the diastolic blood pressure, there is concern for compartment syndrome [2].

Snake venom is often neurotoxic, hemotoxic, or cytotoxic, containing enzymes that cause cell lysis, capillary leak, hematologic coagulopathy or inhibit presynaptic and postsynaptic activity [3]. Antivenom is composed of immunoglobulins designed to bind and neutralize the venom to avoid further damage to cells, and compartment syndrome [4]. Often, timely antivenom administration can prevent systemic effects, but remains problematic in local conditions such as compartment syndrome [5]. However, some have suggested that fasciotomy does not prevent or improve the outcome of toxin mediated muscular necrosis due to snake bites and suggests antivenom alone should suffice [6]. This case report discusses a patient who suffered a rattlesnake bite in his arm, resulting in compartment syndrome refractory to antivenom administration, eventually requiring fasciotomies of his upper arm, forearm, and

☆ Work performed at Detroit Medical Center

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https://doi.org/10.1016/j.tcr.2023.100852
Accepted 24 May 2023
Available online 25 May 2023

hand to salvage his extremity and function. This case report highlights the importance of surgical management for post-snakebite compartment syndrome (PSCS) with confirmed compartment measurements and refutes existing toxicology literature denying the role of fasciotomy in this setting [6,7].

Statement of informed consent

The patient was informed the data and images of his case would be used for publication. He provided full consent to move forward with publication.

Case report

A 56-year-old male with history of deep vein thrombosis (DVT) and pulmonary embolism (PE) on Eliquis who presented after sustaining a snake bite to the right hand around 10:30 pm. The bite was from his pet Eastern Diamondback Rattlesnake. At 1:20 am, received 6 vials of antivenom (Crotalidae). He had been intubated and sedated for an anaphylactic reaction he developed to the envenomation and antivenom which resulted in airway compromise and neck swelling. He was treated with 6 more vials of antivenom at 4:18 am and 10 more vials at 9:39 am. He was treated with 22 vials of antivenom at the point of Orthopaedic consultation around 10:00 am the next morning. He had developed acute respiratory failure, anaphylactic shock, and concern for compartment syndrome of the right upper extremity. The toxicology team stated that compartment syndrome from envenomation would resolve with antivenom administration supported from toxicology literature.

On physical exam, his right upper extremity was tense in the hand, forearm, and upper arm. There was also significant hemorrhaging and bruising throughout the arm. Motor and sensory function was unable to be assessed since he was sedated and intubated. His radial and ulnar pulses were dopplerable. A Stryker needle was used to measure compartments pressures as listed in Table 1. Given the significant elevation of compartment pressures and clinical exam, it was decided to take the patient for fasciotomy of the hand, forearm, and upper extremity. The patient was taken for fasciotomy within 12 h of presentation. Intraoperatively, he had significant muscle herniation upon release of the fascia with signs of myonecrosis (Fig. 1). Over the next thirteen days, he returned to the operating room five times for irrigation and debridement, delayed primary closure, and skin grafting. The skin graft sites were the proximal dorsal forearm (10 × 4.5 cm) and the distal dorsal forearm (12 × 2.5 cm) harvested from the right thigh (Fig. 2).

The patient has two years of established follow-up. He has had no complications of wound dehiscence or infection (Fig. 3). He never attended occupational therapy as requested due to insurance complications. He regained full elbow, wrist, and hand range of motion.

Discussion

This case describes the development of compartment syndrome after an Eastern Rattlesnake bite to the hand refractory to antivenom administration. There is argument in the literature among surgeons and toxicologists whether these injuries are best treated conservatively with antivenom or open surgical compartment release [6–8]. Toxicologists recommend 10–15 vials of antivenom and mannitol as an osmotic diuretic over the first 1 to 2 h for conservative treatment [8]. While some previous cases claim to have success managing patients conservatively for compartment syndrome with antivenom administration, one such report had pressures that did not exceed 30–32 mmHg [8]. It is important to define compartment syndrome as a clinical diagnosis. Patients may present with the five Ps: pain, pallor, pulselessness, paralysis, and paresthesia. It should be suspected in a tense, swollen compartment with pain out of proportion to the mechanism of injury and pain with passive stretch before the other clinical symptoms develop. Compartment pressures are typically only measured when the diagnosis cannot be made clinically, such as in our case since our patient was intubated and sedated.

Cumpston et al. performed a literature review of 640 reports of Crotalinae envenomation and is one of the most highly cited sources

Table 1
Compartment pressure measurements.

Compartment:	Measurement (mmHg)
Forearm:	
Volar	50
Dorsal	37
Mobile wad	29
Hand:	
Thenar eminence	105
Hypothenar eminence	73
Adductor	80
First volar interosseous	82
Second volar interosseous	82
Third volar interosseous	73
First dorsal interosseous	35
Second dorsal interosseous	45
Third dorsal interosseous	42
Fourth dorsal interosseous	57

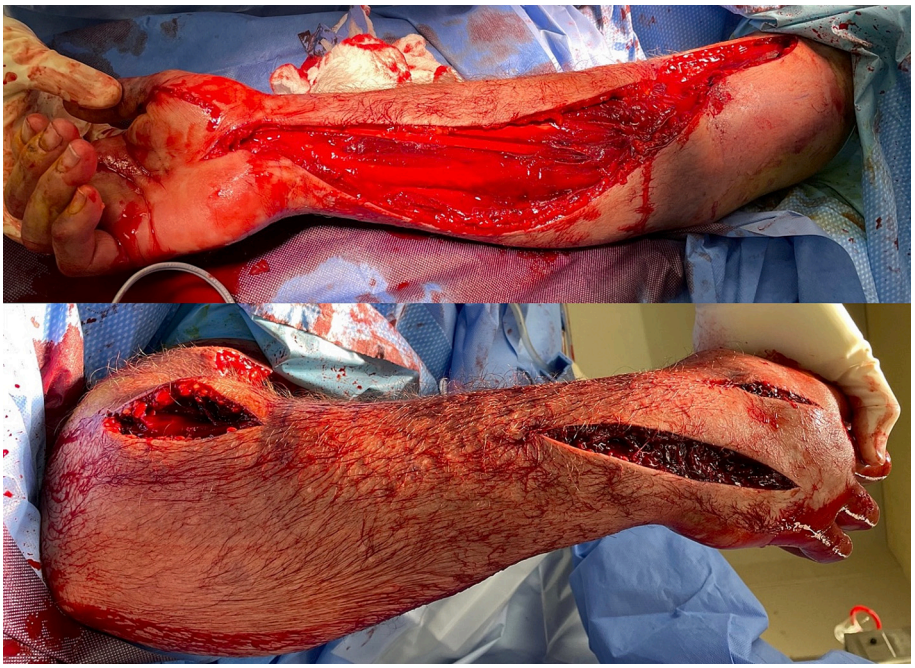

Fig. 1. Released compartments of hand, forearm, and upper arm.

in the argument against fasciotomy for PSCS. The study concluded from animal studies that modern antivenoms lower compartment pressures, increase tissue perfusion, increase survival, and decrease hemorrhage. They recommend against fasciotomy as they claim there are no studies providing evidence that fasciotomy decreases myonecrosis or relieves the intercompartmental pressures from envenomation [6]. Literature has shown irreversible changes to peripheral nerves and musculature as soon as 8 h from the development of compartment syndrome and recommend prompt fasciotomy for limb salvage [2]. Our case involved a patient 12 h from initial envenomation and 10 h from initial antivenom administration with persistent pressures >100 mmHg. While we do not deny the utility of antivenom in snake envenomation, we strongly disagree with there being no role for fasciotomy in cases of PSCS with confirmed compartment measurements refractory to an adequate trial of antivenom per toxicology recommendations.

The patient in this case was actively taking Eliquis for a history of deep vein thrombosis and pulmonary embolism. There have been previous case reports of the development of compartment syndrome following minor trauma to extremities in patients on blood thinners, including one from Eliquis [9]. Patients on Eliquis are known to be at an increased risk for hematoma development which likely compounded the venom's coagulopathic effects [9]. Prior to fasciotomy, our patient had an elevated international normalized ratio (INR) of 1.85, an elevated prothrombin time (PT) of 19.2, a normal partial thromboplastin time (PTT) of 24.2, elevated of D-Dimer of 18, and a fibrinogen level <50. In addition, there was a thromboelastogram (TEG) consistent with the static hemostasis markers concerning for his inability to form a clot, further motivating our team to move forward with surgical intervention. Post-operatively, the patient's Eliquis was held, and he completed the antivenom course. His hemostatic markers returned to baseline within 24 h of the procedure. Further research is needed to understand the effects of different blood thinners on snake envenomation outcomes.

There are now FDA approved continuous compartment pressure measurement devices such as MY01 (NXTSens Inc., Montreal, Canada) to aid in the diagnosis of compartment syndrome. The accuracy and utility of the MY01 outperformed more commonly used devices such as the Stryker (Stryker Inc., Kalamazoo, MI, USA) or Synthes systems (Depuy-Synthes Inc., West Chester, PA, USA) [10]. The major advantage is the ability to continuously monitor patient's compartment measurements over many hours and not have to repeat invasive measurements [10]. This device would have been particularly useful in this case and the monitoring for compartment syndrome following snake envenomation where a clinical exam cannot be performed. The toxicology antivenom regimen can be administered while the compartments are monitored for the potential need for fasciotomy.

The limitation to the study is that this is a single case report from our institution. We do not receive many snake bite cases at our hospital and even less-so cases that develop compartment syndrome.

Overall, the decision to proceed with operative intervention versus conservative management with antivenom in the case yielded a salvaged and functional limb. While the majority of snake bites will be managed successfully with antivenom, a minority of case will develop compartment syndrome. Open surgical compartment fasciotomy should be performed in the setting of post-snakebite compartment syndrome (PSCS).

Fig. 2. Post-op incisions closed primarily ventrally and skin grafts dorsally.

Fig. 3. Healed incisions and skin grafts two years post-op.

Conclusion

This is a case of a patient who suffered post-snakebite compartment syndrome from his pet Eastern Diamondback Rattlesnake. This case highlights the importance of correctly diagnosing compartment syndrome and validates fasciotomy as a treatment measure for confirmed post-snakebite compartment syndrome (PSCS).

Declaration of competing interest

No author in this study has any conflicts of interest.

Acknowledgements

None.

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