Am. J. Trop. Med. Hyg., 106(1), 2022, pp. 338–341
doi:10.4269/ajtmh.21-0374

Case Report: Safe Tourniquet Removal in Black Mamba (*Dendroaspis polylepis*) Bites

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Abstract. The black mamba is known for its notorious potent neurotoxic venom. For this reason, their bites are often erroneously treated in the field with the application of a tourniquet in the hope of delaying systemic spread of the venom. Observational studies have shown that inappropriate tourniquet application is a common, harmful practice. An arterial tourniquet is not a recommended first aid measure because of the risk of limb ischemia and gangrene. When inappropriately applied, the rapid removal of the tourniquet in the emergency department may precipitate a life-threatening venom and metabolic toxin rush, leading to respiratory arrest. We present two cases of black mamba bites in Gauteng, South Africa, where gradual tourniquet removal was used to avoid a venom rush and rapid respiratory paralysis. Venom and metabolic toxin rush with potentially fatal respiratory muscle paralysis may be averted by gradual, cautious removal of field-applied tourniquets with concomitant antivenom administration.

INTRODUCTION

The WHO states that snakebites are a neglected tropical disease, and in Africa, approximately 20,000 people die of snakebites every year.[1,2] The black mamba is considered the most venomous snake in Africa and is responsible for numerous deaths annually.[3] However, little is known or done to try to limit these deaths. Observational studies have shown that inappropriate tourniquet application is a common harmful practice.[4,5] An arterial tourniquet is not a recommended first aid measure because of the risk of limb ischemia and gangrene.[6] Rapid release exposes patients to cardiorespiratory arrest due to a venom and metabolic toxin rush.[5,7] A single observational study of bites from the Philippine cobra (*Naja philippinensis*) and anecdotal case reports of mamba bites have described a precipitous systemic envenomation that occurs after rapid tourniquet release in the emergency department (ED) known as "venom rush."[5] Proper first aid measures can never be over-emphasized. Current recommendations for the first aid management of neurotoxic snakebites are the application of a pressure bandage, immobilization of the affected limb and rapid conveyance of the patient to a medical facility.[8,9]

We report two cases of black mamba bites in which tight tourniquets had inadvertently been applied before arrival to our ED. In both cases, infusions of South African Vaccine Producers (Johannesburg, South Africa) polyvalent antivenom (PAV) were initiated, followed by gradual tourniquet release. Although both patients displayed neurotoxic symptoms, neither required mechanical ventilation. By comparing arterial blood gases (ABG) on the tourniqueted and nontourniqueted arms, we found evidence that both patients had a significant buildup of metabolic toxins in their tourniqueted arms. We postulate that the controlled release of these tourniquets prevented venom rush and the need for mechanical ventilation.

CASE 1

A 24-year-old male patient was bitten twice on the left hand by his black mamba. He was brought in by the Emergency Medical Services (EMS). EMS had tied a tight bandage-tourniquet around his arm. He maintained normal vital signs and a Glasgow Coma Score of 15/15 at the scene and during transportation. His saturation was 98% on nasal prongs at 2 L/minute. A large bore intravenous (IV) line was placed in the uninjured arm.

On arrival the patient had a cyanosed left arm with a tight tourniquet around it. Ongoing fasciculations were noted on his chest, face, and abdomen, with bilateral ptosis. He complained of pain in the tourniqueted arm. Analgesia was given and 0.25 mg adrenaline administered subcutaneously. An infusion of 12 vials of PAV in normal saline was given over half an hour. An inflatable tourniquet was applied proximal to the bandage-tourniquet and pumped up to 150 mm of Hg. The latter was then removed. During antivenom administration the patient developed urticaria, which responded to promethazine. The inflatable tourniquet was set to deflate incrementally over half an hour. Upon removal, the patient no longer displayed ptosis or fasciculations. He was monitored with capnography and 4-hourly peak expiratory flow rates to detect any rebound neurotoxicity. His stay was uneventful until discharge. Before tourniquet removal, an ABG of both radial arteries was taken to compare the metabolic conditions of the two arms (Figure 1). The results are illustrated in Table 1.

CASE 2

A 50-year-old male herpetologist was bitten on his left pinkie finger by a black mamba (Figure 2) while cleaning its cage. Figure 3 shows the bite site. An inflatable blood pressure cuff was applied to the patient's bitten limb and pumped until the radial pulse was no longer palpable. This was done by the patient as a first-aid measure within minutes of the bite. EMS arrived at the scene and transported him to the nearest hospital an hour away. He arrived at our ED, 2 hours after application of the cuff tourniquet.

On arrival, the patient complained of severe pain in his arm, which appeared mottled and cyanotic. He was diaphoretic but experienced no fasciculations or other neurological symptoms. His vital signs and oxygen saturations were normal. ABGs were taken from both arms (Figure 4).

While preparations were made to administer PAV, the arm and tourniquet was assessed, demonstrating a metabolic toxin buildup on ABG in the affected arm (Table 2). Then, 0.25 mg of subcutaneous adrenaline was administered

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FIGURE 1. Arterial blood gases from the affected arm on the left versus the unaffected arm on the right. Notice the darker color of the blood from the affected arm. This figure appears in color at www.ajtmh.org.

prophylactically. Ten vials of PAV were added to normal saline and infused over 30 minutes. After initiation of PAV the cuffed tourniquet was deflated incrementally every 5 minutes until it was completely removed.

The arm reperfused uneventfully, and the patient was admitted for a 72-hour observation period, which included continuous pulse oximetry and 4-hourly peak flow measurements. His recovery was uneventful.

DISCUSSION

In Australia, most venomous snake bites are caused by neurotoxic elapids, and therefore the application of a pressure bandage to delay systemic absorption is recommended.[9,10] In North America, venomous bites are caused by cytotoxic crotaline species.[11,12] Given concern that pressure bandages could worsen tissue damage, the American College of Medical Toxicology and American Association of Poison Control Centers made the following joint statement: "Available evidence fails to establish the efficacy of pressure immobilization in humans but does indicate the possibility of serious adverse events arising from its use."[11,12]

TABLE 1
Arterial blood gases parameters of patient 1 demonstrating the metabolic differences in his arms

Blood gas parameters	Unaffected arm	Tourniqueted arm
pH	7.365	7.118
$PaCO_2$	32.9	68.7
PaO_2	120	57.2
K	3.3	4.3
Na	134	137
Lactate	4.1	8.6

FIGURE 2. Black mamba (*Dendroaspis polylepis*) that bit patient 2. This figure appears in color at www.ajtmh.org.

In southern Africa, snakes with neurotoxic and cytotoxic venoms are common.[4,6] This makes a blanket statement on the use or disuse of pressure bandages problematic. Although its use may be recommended for neurotoxic snakebites, it is considered detrimental for cytotoxic envenomation. Tourniquet use is highly controversial. It is generally condemned as a first-aid measure for snake bites, although it has been recommended by some experts who refer to anecdotal

FIGURE 3. Patient 2's bite mark. This figure appears in color at www.ajtmh.org.

FIGURE 4. Arterial blood gases from patient 2. On the left is blood from the affected arm versus unaffected arm on the right. This figure appears in color at www.ajtmh.org.

cases.[4,5,7,10] Observational studies have shown that tourniquets are widely used by the lay public for snake bites.[4,6]

As a general principle, tourniquets must be removed as soon as possible to limit tissue damage and improve perfusion. However, one observational study on 34 Philippine cobra bites and anecdotal cases of mamba bites suggest that rapid tourniquet removal leads to precipitous respiratory compromise.[5] In both of our cases there was evidence of the buildup of metabolic toxins in the tourniqueted arms. Release of such toxins may pose a risk to patients, especially in combination with venom. Because both patients survived their confirmed mamba bites without the need for mechanical ventilation, we propose that our two cases provide observational evidence for gradual tourniquet release in confirmed black mamba bites. The authors do not condone the use of tourniquets but recommend that they be released in a controlled manner under specific circumstances (prolonged application in black mamba bites).

LIMITATIONS

We were unable to measure venom toxicity levels. Therefore, we have no direct evidence for an elevated concentration of venom in the affected limbs as opposed to the rest of the body. We can only indirectly infer so, due to the delay in neurologic symptoms and the accumulation of metabolic toxins in the affected arms for which there was clear evidence.

These are two case studies which provide a low level of evidence for gradual tourniquet release after black mamba envenomation when tourniquets had been applied. The value of this intervention can only be confirmed or rejected based on well-constructed studies to further evaluate the intervention.

TABLE 2
Arterial blood gases parameters of patient 2

Blood gas parameters	Unaffected arm	Tourniqueted arm
pH	7.36	6.769
$PaCO_2$	30.7	116
PaO_2	110	5.4
K	3.4	9.4
Na	136	134
Lactate	1.2	18

CONCLUSION

We conclude that our two cases demonstrate excellent outcomes after the controlled, gradual removal of tourniquets with simultaneous antivenom administration. Neither of our patients required mechanical ventilation, developed a venom rush, required further antivenom administration, or suffered permanent limb damage. We propose that gradual, controlled tourniquet release appears to be a safe method after neurotoxic envenomation. In a patient with a tourniquet applied, there is a delicate balance between immediate removal of the tourniquet to avoid ischemic damage and gradual removal to prevent a venom rush.[5] On the basis of these two cases, we recommend gradual release on symptomatic black mamba bites where a tourniquet has been applied. Although we have no specific evidence as to the rate of release, we propose the following: If a patient arrives with a tight tourniquet in situ after a confirmed black mamba bite, the clinician should apply an inflatable blood pressure cuff to the affected limb. The cuff should be inflated to 10 mm Hg above the patient's systolic blood pressure. The constricting tourniquet may then be removed. Once the antivenom has been initiated, the inflatable cuff tourniquet may be released by 5 to 10 mm Hg every 5 minutes until the diastolic pressure is reached. By making use of this method, tourniquet release should take no longer than 30 minutes, which is the time that is usually taken for antivenom administration.

Received April 17, 2021. Accepted for publication July 16, 2021.

Published online November 1, 2021.

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