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# Hyperbaric oxygen therapy after *Bothrops lanceolatus* snake bites in Martinique: A brief report

P. HOCHEDÉZ<sup>1</sup>, L. THOMAS<sup>2</sup>, H. MEHDAOUI<sup>3</sup>

<sup>1</sup> Infectious Disease Department, <sup>2</sup> Emergency Department and <sup>3</sup> Intensive Care Unit, Teaching Hospital, Fort de France, Martinique, France

CORRESPONDING AUTHOR: Dr. Patrick Hochedez – [p.hochedez@free.fr](mailto:p.hochedez@free.fr)

## ABSTRACT

Every year 10 to 20 cases of snake bites are reported on the Caribbean island of Martinique. The only snake involved, *Bothrops lanceolatus*, is endemic on the island, and its bite may lead to systemic multifocal thrombotic complications in the absence of the monospecific antivenom. Between January 1988 and January 2009, more than 250 snake bites have been reported, and five patients were treated with hyperbaric oxygen (HBO<sub>2</sub>) therapy for local complications. The patients were male, bitten on the leg or the hand, and presented with severe complications such as necrotizing soft tissue infections, compartment syndrome or abscesses despite prompt wound care and administration of antivenomous serum. Outcomes were favorable for these five patients, except for one who was left with a functional defect of the hand. Although snake bites are not part of the currently recommended indications for HBO<sub>2</sub> therapy, local complications, namely compartment syndrome, necrotizing soft tissue infections and enhancement of healing in selected problem wounds, are approved uses of HBO<sub>2</sub> therapy as defined by the Hyperbaric Oxygen Therapy Committee and would benefit from prospective studies.



## INTRODUCTION

Every year 10 to 20 cases of snake bites are reported in Martinique, one of the Caribbean Windward Islands. *Bothrops lanceolatus*, a member of the subfamily *Crotalinae*, which is endemic in Martinique, is the only snake involved [1]. The genus *Bothrops* contains most of the South American pit viper fauna; two species of *Bothrops* are endemic in the Windward Islands: *Bothrops caribbaeus* in St. Lucia, and *Bothrops lanceolatus* in Martinique [2].

Contrary to the envenoming by South American *Bothrops*, which leads to coagulopathies and systemic bleeding, the severity of envenoming by *B. lanceolatus* is due to the development of systemic multifocal thrombotic complications, mainly cerebral, myocardial or pulmonary infarctions that may appear within the first week in approximately 30 percent of envenomed patients in the absence of the monospecific *B. lanceolatus* antivenom [1,3]. Apart from thrombotic complications, envenomation by this snake leads to immediate local symptoms, including intense pain, swelling and bleeding at the site of the bite, which are common to most crotalid envenomings [3]. Serious

local complications may occur over time, such as local necrosis, primary bacterial infections and extensive swelling involving the whole bitten limb and the trunk [1, 4, 5]. In a study carried out on 103 patients bitten by *B. lanceolatus*, more than one-third of the patients with severe envenoming presented primary bacterial infection [4].

## METHODS

We retrospectively identified patients treated with hyperbaric oxygen (HBO<sub>2</sub>) therapy for complications of snake bite in the Teaching Hospital of Fort de France, Martinique, between January 1988 and January 2009. Epidemiological data were recorded together with data concerning the circumstances of the bite, early symptoms, local and general complications and HBO<sub>2</sub> treatment modalities.

## RESULTS

Between January 1988 and January 2009, five patients were treated by HBO<sub>2</sub> therapy for snake bite complications. Clinical and therapeutic information are summarized in Table 1 (Page 400). All patients were

**TABLE 1 — Clinical and therapeutic information**

Patient	Localization of the bite	Complications	Surgery	Antibiotics	HBO <sub>2</sub> 2.2 ata (no. of treatments)
1	right hand	compartment syndrome, palmar necrosis	fasciotomy	penicillin + metronidazole	15
2	right calf	cutaneous necrosis, compartment syndrome <i>Proteus vulgaris</i> abscess	fasciotomy, drainage of the abscess	penicillin then cefotaxime, netilmicin and metronidazole	9
3	left ankle	<i>Aeromonas hydrophila</i> bacteremia, <i>Aeromonas hydrophila</i> and <i>Moragnella morganii</i> abscess	drainage of the abscess	cefotaxime pefloxacin and netilmicin	7
4	left hand	cutaneous necrosis necrotizing fasciitis, <i>Aeromonas hydrophila</i> bacteremia	surgical excision of the tissue	penicillin then cefotaxime and netilmicin	7
5	left leg	abscess	drainage of the abscess	penicillin G and metronidazole	1

male. Patient age ranged from 20 to 65 years, with a mean age of 45.2 years. The size of the snake was reported in four cases and ranged from 80 to 230 cm, with a mean size of 145 cm. Three patients were bitten on the leg and two on the hand. Initial presentations were marked by local edema and intense pain. Specific antivenomous serum was administered to all patients within the first hours after the bites. Sero-vaccination against tetanus as well as analgesia, anticoagulants and prophylactic antibiotic were additionally given to the patients. All patients had one or more of the following complications:

- local abscess for three;
- cutaneous necrosis for three;
- compartment syndrome for two;
- bacteremia for two; and
- necrotizing fasciitis for one.

Diagnosis of compartment syndrome was made by the attending physicians, and compartment pressures were not measured. All patients required one or more surgeries. HBO<sub>2</sub> therapy sessions were given at 2.2

atmospheres (222.9 kilopascals) and a 100 percent inspired oxygen fraction on a daily basis as an adjunct to the surgical treatments. The number of HBO<sub>2</sub> sessions ranged from 1 to 15, depending on clinical presentation. Patients had favorable outcomes, except a fixed flexion deformity of the third finger and a sensitivity impairment of the fourth finger for one patient.

## DISCUSSION

Over the last 20 years, five patients were treated with HBO<sub>2</sub> therapy in the Teaching Hospital of Fort de France, following a *Bothrops lanceolatus* snake bite. The five patients were male, with leg or hand bites, as is usually reported in the literature [1,4,6]. The patients were treated according to local specific protocol, comprising urgent administration of antivenomous serum, prophylactic antibiotics, tetanus prophylaxis and local disinfection [4]. Early infusion of antivenom is the only truly effective treatment for prevention of severe thrombotic accidents encountered after bites of the snake *B. lanceolatus* [1,4,6].

Even though this treatment is administered and early wound care and prophylactic antibiotics are delivered, local necrosis and severe infections may still occur, as reported in our patients. These complications seem to be associated with the amount of injected venom, the bacterial inoculation into the wound and the anatomic site of the bite.

Snake bites, as such, are not one of the currently recommended indications for hyperbaric oxygen therapy. However, the following indications, which can occur as complications of snake bites, are approved uses of hyperbaric oxygen therapy as defined by the Hyperbaric Oxygen Therapy Committee:

- compartment syndrome;
- necrotizing soft tissue infections; and
- enhancement of healing in selected problem wounds [7].

The occurrence of a compartment syndrome after a snake bite results from local envenomation, local edema and the depth of bite [5]. Compartment syndrome leads to occlusion of the microcirculation and to consequential ischemia and cellular edema, which can perpetuate the syndrome [8]. The postulated mechanisms of a beneficial effect of adjunctive HBO<sub>2</sub> therapy on compartment syndrome include: edema reduction due to hyperoxic vasoconstriction; protection from reperfusion injury and enhanced wound healing [9-11].

Numerous non-randomized studies have reported the beneficial effect of adjunctive HBO<sub>2</sub> therapy on compartment syndrome associated with acute traumatic ischemic injury [12-15]. At the time of publication, we find a unique but striking case report of the beneficial effect of HBO<sub>2</sub> on compartment syndrome after snake envenomation. A 43-year-old man intentionally allowed a western diamondback rattlesnake (*Crotalus atrox*) to bite him on the hand, in an attempt to bolster his immunity to the venom [16]. In spite of early antivenom administration, a compartment syndrome occurred. Because of patient reluctance to undergo the recommended surgery, three HBO<sub>2</sub> therapy sessions were given at 2.4 atmospheres, preventing the need for fasciotomy [16]. This case report and our two cases, for which HBO<sub>2</sub> was administered as adjunctive therapy to fasciotomy, emphasize the need for further studies to evaluate hyperbaric oxygen therapy when compartment syndrome is diagnosed after snake envenomation.

Bacterial inoculation after a snake bite may lead to severe infective complications such as abscess, necrotizing soft tissue infection, clostridial myonecrosis and bacteremia [4,5,17,18,19]. All the factors which impair local microcirculation (vascular thrombosis, edema) contribute to tissue anoxia, increase bacterial growth and decrease the possibilities of elimination of the venom [20,21]. In a study involving 103 patients envenomed by *Bothrops lanceolatus* in Martinique, more than one-third of the severe cases presented with a primary bacterial infection, mainly associated with *Proteus vulgaris*, *Morganella morganii*, *Aeromonas hydrophila* and *Staphylococcus aureus*. [4]. The natural environment of bacteria *A. hydrophila* is brackish water. This bacteria has been isolated from bite wounds by *B. lanceolatus* but also in crocodile, piranha and shark bites [19,22].

The postulated mechanisms of the anti-infective effects of HBO<sub>2</sub> therapy are due to the rise of the oxygen partial pressure in ischemic tissues, which strengthens the phagocytic capacities of neutrophils, leads to bacteriostatic effects for some aerobic bacteria and bactericidal effects for certain anaerobes, and also suppresses clostridial production of alpha toxin [23-29]. Since its first administration as adjunctive therapy for gas gangrene in 1961, numerous non-randomized studies have reported the beneficial effect of HBO<sub>2</sub> therapy on gas gangrene and necrotizing fasciitis [10,26,30-32]. Necrotizing soft tissue infection is a severe local complication of snake bites, and HBO<sub>2</sub> therapy should be promptly considered as an adjunctive therapy to surgery and antibiotic treatment.

Severe local necrosis is a usual complication of viperid envenomation and is related to the inoculation of component toxins such as phospholipases A2 and proteinases [5,21,33]. The severity of the lesion depends on the quantity of inoculated venom and may lead to major esthetic and functional aftereffects, particularly for hand bites [5]. Enhancement of healing in selected problem wounds is part of the approved indications of HBO<sub>2</sub> by the Hyperbaric Oxygen Therapy Committee [7]. The postulated mechanisms are the promotion of fibroblast replication, collagen matrix and angiogenesis [34,35]. The effect of hyperbaric oxygen on cutaneous necrotic complications after snake bites have not been published to date.

Necrotic ulcerations are severe complications of envenomation from the brown recluse spider (*Loxosceles reclusa*). The treatment of *L. reclusa* bites re-

mains controversial, and HBO<sub>2</sub> as been proposed as a therapeutic approach to the necrotic wounds resulting from the brown recluse bite [36]. An experimental study in a rabbit model has shown the benefit of hyperbaric oxygen treatments to decrease wound diameter [37]. Its benefit for patients has also been reported in case series with a diminution of surgical intervention to achieve complete healing [36]. As for the treatment of brown recluse envenomations, the potential benefit of HBO<sub>2</sub> therapy for necrotic ulceration occurring after snake bites require specific studies, and to date no recommendations should be made.

## CONCLUSION

The fundamental parameter in the care of the bites of *Bothrops lanceolatus* is the prompt administration of the specific antivenomous serum. However, despite early serotherapy, the bitten patients may present severe local complications such as necrotizing soft tissue infections, compartment syndrome and necrotic ulcerations. Elective bite localizations, particularly hand bites, may lead to major functional after-effects, so the most conservative treatment is helpful. When such complications occur, hyperbaric oxygen treatment should be promptly discussed as an adjunctive treatment to surgery and antibiotic treatment, with the aim to improve the immediate prognosis and decrease long-lasting functional complications.



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