

REVIEW

Central and South American pit vipers

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Pit vipers are the predominant venomous serpents of Central and South America. Their bites cause substantial local tissue destruction and other morbidity and if untreated cause significant mortality. Primary treatment is with intravenous equine derived antivenom.

Key words: pit vipers; Central America; South America; *Crotalidae*

Introduction

The clinically important venomous snakes of Central and South America are pit vipers, family *Crotalidae* (previously named *Viperidae*), and include the genera *Bothrops*, *Crotalus* and *Lachesis*. Eighty-five per cent of bites are inflicted by *Bothrops*, 10% by *Crotalus*, 1% by *Lachesis* and the remainder by other venomous serpents, primarily coral snakes of the family *Elapidae*. The clinical presentations and recommended treatments are similar for the South American pit vipers and are therefore included in this paper.

Biology

A dazzling saffron sun blazed down upon the small Caribbean isle of Martinique and stirred the lush, highland vegetation. The sea tempered heat swept past lowland sugarcane and caressed its leaves into a sonorous drone. Lifted by the breeze, the sweet scent of frangipani permeated the air. Slender palm trees laden with fruit danced amid flights of multicolored parrots. Crimson hibiscus flowers burst from the landscape as if fired from cannons while insects hummed in orchestration across the kaleidoscopic battlefield.

Colorless by comparison, the erect stalks of sugarcane in the lowlands below pushed 20 ft into the air in a race for the sun. Ready for harvest, the cane was laden with the syrupy sap that would be processed into the sugar and molasses. Below the towering cane, a long line of men bent to their work. Suddenly a cane cutter faltered in the heat. As his fingers neared the cane, there was a blur of movement and, in one swift stroke, his hand was struck an agonizing blow. Below him, coiled defensively in the filtered light beneath the leafy nodes of cane, lay a fer-de-lance.

French for 'head of the lance' or 'spear', the name fer-de-lance describes the snake's distinctively-shaped head. Although the name applies strictly to the Martinique species, it is often used collectively to describe all Central and South American snakes belonging to

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Table 1. Members of the genus *Bothrops*

<i>Species</i>	<i>Common name</i>	<i>Distribution</i>
<i>B. alternatus</i>	Urutu	Brazil, Paraguay, Argentina
<i>B. ammodytoides</i>	Patagonian lance-head	Argentina
<i>B. andianus</i>	Andean lance-head	Peru
<i>B. asper</i>	Terciopelo	Southern Mexico, Central America, North South America
<i>B. atrox</i>	Common lance-head	South America except Chile, Paraguay, Uruguay and Argentina
<i>B. barnetti</i>	Barnett's lance-head	Peru
<i>B. brazili</i>	Brazil's lance-head	Northern and Central South America
<i>B. carribbaeus</i>	Saint Lucia lance-head	Saint Lucia Island, Lesser Antilles
<i>B. cotiara</i>	Cotiara	Argentina, Brazil
<i>B. erythromelas</i>	Caatinga lance-head	Northeast Brazil
<i>B. fonsecai</i>	Fonseca's lance-head	Southeast Brazil
<i>B. iglesiassi</i>	Sertao lance-head	Piaui, Brazil
<i>B. insularis</i>	Golden lance-head	Ilha Queimada Grande Brazil
<i>B. itapetiningae</i>	Sao Paulo lance-head	Southcentral Brazil
<i>B. jararaca</i>	Jararaca	Brazil, Paraguay, Argentina
<i>B. jararacussu</i>	Jararacussu	Brazil, Paraguay, Southern Bolivia, Northeast Argentina
<i>B. lanceolatus</i>	Martinique lance-head	Martinique, West Indies
<i>B. leucurus</i>	White-tailed lance-head	Bahia, Brazil
<i>B. lojanus</i>	Logan lance-head	Southern Ecuador
<i>B. marajoensis</i>	Marajo lance-head	Extreme Northern Brazil
<i>B. microphthalmus</i>	Small-eyed lance-head	Colombia, Ecuador, Peru
<i>B. moojeni</i>	Brazilian lance-head	Brazil, Paraguay
<i>B. neuwiedi</i>	Neuwied's lance-head	Brazil, Paraguay, Bolivia, Uruguay, Argentina
<i>B. pictus</i>	Desert lance-head	Costal Peru
<i>B. pirajai</i>	Piraja's lance-head	Bahia, Brazil
<i>B. pradoi</i>	Prado's lance-head	Espirito Santo, Brazil
<i>B. pulcher</i>	Dusky lance-head	Coastal Northwestern South America
<i>B. roedingeri</i>	Roedinger's lance-head	Ica, Peru
<i>B. sanctaerucis</i>	Bolivian lance-head	Central Bolivia
<i>B. venezuelensis</i>	Venezuelan lance-head	Northern Venezuela
<i>B. xanthogrammus</i>	Cope's lance-head	Southen Ecuador

the genus *Bothrops*. Currently, 31 species of *Bothrops* are recognized [1]. These are listed with their common names and distributions in Table 1.

Distinguished by sensory pits between the eyes and nostrils and the sharply-defined canthus, or up-turned nose, lance-heads belong to the group of snakes known as the pit-vipers (family Crotalidae or subfamily Crotalinae) [2]. Drab and cryptically-colored, they are usually gray or brown with dark blotches on the back. Because they superficially

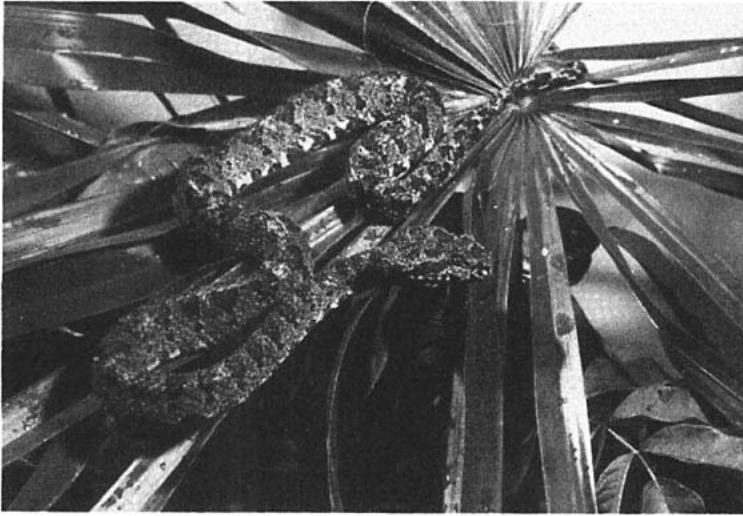


Fig. 1. *B. schegeli* – the eyelash viper.

resemble one another in appearance and because their color and pattern are highly variable, they are difficult to distinguish by color alone. Species and subspecies classification is done by counting the scale patterns on the head and by noticing differences in the hemipenes (male copulatory organs).

Most lance-heads occur on mainland South America, although *B. asper* occurs through Central America, north into Mexico, and on the island of Trinidad. Three endemic insular species are recognized: *B. caribbaeus* on Saint Lucia, *B. lanceolatus* on Martinique in the West Indies and *B. insularis* on Ilha Queimada Grande off the coast of Brazil [1]. *B. schegeli*, the eyelash viper, is shown in Figure 1.

Lance-heads are primarily terrestrial, although they may climb. A few, like *B. lanceolatus*, *B. insularis* and *B. caribbaeus*, are semi-arboreal. Although they primarily inhabit lowlands at elevations of less than 1500 m (4800 ft), they tolerate a wide variety of environments and range from dry habitats near sea level to cloud forests more than 2500 m (8000 ft) in elevation. Table 2 details the habitat variation for the genus *Bothrops*. *B. andianus* in South America lives as high as 3300 m (more than 10000 ft). Their size varies greatly. Some seldom exceed 60 cm (24 in), while others reach more than 2.5 m (8 ft) [1, 3].

Because they exist in many habitats and are abundant in cultivated regions, lance-heads are an important cause of human snakebite. They are responsible for more human morbidity than any other group of venomous snakes in the New World, including rattlesnakes, moccasins and coral snakes. Most bites are attributed to *B. asper* in Central America and *B. atrox* and *B. jararaca* in South America, although several other species, like *B. neuwiedi* in southern South America, are also medically important [1].

B. asper, the terciopelo, ranges from northeastern Mexico through Central America and into northern South America. It is the only lance-head occurring on the mainland north of Colombia. Terciopelo means 'velvet', which refers to the snake's velvet-like appearance, but it is known by many regional names. In some areas of Mexico and in

Table 2. Habitat variation for *Bothrops*

<i>Species</i>	<i>Features</i>	<i>Habitat</i>	<i>Notes</i>
<i>B. alternatus</i>	Large, heavy, to 169 cm	Lowland swamps, marshes, rivers, common on sugar cane plantations	Bites common, seldom fatal
<i>B. ammodytoides</i>	Stocky, to 100 cm	Savannas, steppes, sandy, rocky areas	Irritable temperament, potentially dangerous
<i>B. andianus</i>	Small, to 70 cm	Wet montane forest	
<i>B. asper</i>	Large, not heavy, to ≥ 250 cm	Varied, primarily tropical forests near rivers	Frequently encountered, dangerous
<i>B. atrox</i>	Large, heavy to 200 cm	Varied, primarily close to water, including urban/cultivated areas	Major cause of snakebite, potent venom, dangerous
<i>B. barnetti</i>	Stout, to 809 cm	Arid desert scrub	
<i>B. brazili</i>	Stout, to 140 cm	Lowland tropical forest, in leaf litter	No reports of bites
<i>B. carribbaeus</i>	Large, to ≥ 200 cm	Lowland tropical forest, including cultivated areas	Deaths from bites recorded
<i>B. cotiara</i>	Heavy, to 100cm	Temperate forest, savanna	
<i>B. erythromelas</i>	Slender, to 79 cm	Arid forest, open rocky area	
<i>B. fonsecai</i>	Heavy, 87 cm (one record)	Coastal forest	
<i>B. iglesiasi</i>	Slender, to 66 cm	Arid rocky areas	
<i>B. insularis</i>	Slender, to 100 cm	Arid scrub, rocky areas	
<i>B. itapetiningae</i>	Small, stocky to 50 cm	Open fields, bushy areas	
<i>B. jararaca</i>	Slender, to 160 cm	Varied, prefers open areas close to vegetation	Important cause of snakebite
<i>B. jararacussu</i>	Large, heavy, to ≥ 220 cm	Tropical forests, primarily along rivers	Large venom capacity, important cause of snakebite
<i>B. lanceolatus</i>	Large, to ≥ 200 cm	Wet, tropical, upland forests	Deaths from bites recorded
<i>B. leucurus</i>	Slender, to 112 cm	Valley forest	
<i>B. lojanus</i>	Stocky, to 61 cm	Dry montane forests	
<i>B. marajoensis</i>	Medium build, to 150 cm	Lowland savanna	
<i>B. microphthalmus</i>	Heavy, to 136 cm	Low montane wet/cloud forest	
<i>B. moojeni</i>	Large, to ≥ 168 cm	Semi-arid tropical savanna	
<i>B. neuwiedi</i>	Medium build, to 155 cm	Semi-arid savanna/forest/thorn scrub	Important cause of snakebite

Table 2. continued

<i>Species</i>	<i>Features</i>	<i>Habitat</i>	<i>Notes</i>
<i>B. pictus</i>	Stocky, to 100 cm	Arid/semi-arid hills/ valleys; dry rocky areas	Dangerously venomous, deaths from bites recorded
<i>B. pirajai</i>	Stocky, to 113 cm	Wet lowland/coastal forest, cocoa groves	
<i>B. pradoi</i>	Slender, to 115 cm	Presumably tropical forest	
<i>B. pulcher</i>	Stout, to 75 cm	Tropical forests near rivers	No reports of bites
<i>B. roedingeri</i>	No adult measurements	Coastal/foothill deserts	
<i>B. sanctaerucis</i>	Medium build, total length unrecorded	Low montane wet forest	
<i>B. venezuelensis</i>	Large, to 152 cm	Low montane wet/cloud forest	
<i>B. xanthogrammus</i>	Large, 154 cm (one record)	Low montane forest	

many areas in Central America, locals call it *barba amarilla*, or 'yellow beard', a reference to its yellow throat. Other locals in Mexico call it *cuatro narices*, or 'four nostrils', referring to the additional two heat pits on the end of the snout. Belizeans call it the yellow-jaw tommygoff and Colombians call it *equis negra*, or 'black cross', referring to a series of dark crosses that are visible on its back. The crosses may be indistinct or resemble other species, so its color and pattern are not reliable characteristics for its identification [1, 4].

The terciopelo is primarily a lowland forest form, found from sea level to 1300 m (4100 ft), but ranges into higher elevations in South American cloud forests. Frequenting the environs of rivers and other bodies of water, adults rarely climb above ground. Young animals are more arboreal, often seeking refuge in bushes and low trees. As with all members of the group, they are inactive during the day and active at night when they hunt for small, warm-blooded animals.

Although relatively slender, the terciopelo is the largest of the lance-heads, reaching more than 2.5 m (8 ft) in length. Most adults, however, measure between 1.2–1.8 m (4–6 ft). They are irascible when disturbed; they move and strike rapidly. Often encountered in lowland areas, their excitable nature and large size heighten their potential danger to humans [1].

The common lance-head, *B. atrox*, is the most widely distributed species of the group, ranging throughout most of South America. It is absent only from Paraguay, Uruguay and Chile. It is frequently confused with *B. asper* and it also bears the names *barba amarilla* and *equis negra*. Like the terciopelo, it lives in a wide variety of habitats, preferring tropical forests near water. However, it is abundant in and around the fields, vacant lots, trash heaps and buildings of both cultivated and urban areas where rodents abound [5].

Although not as large as the terciopelo, the common lance-head is stouter and heavier, growing to about 1 m (3 ft) in length. Its color, pattern and habits are typical for the group. A propensity for living near people and a potent venom makes it one of the most medically important snakes in the tropics.

The most southerly resident of the three, the jararaca (*B. jararaca*) occurs in Argentina, Paraguay and southern Brazil, where it is also referred to as the yararaca and yarara. It is a slender species, rarely reaching 1.6 m (5 ft) in length. As with the others, its color, pattern and living habits are diverse, but atypically, it prefers open areas. For this reason, it is particularly abundant in cultivated fields and accounts for a large number of snakebites [1, 2].

Crotalus durissus terrificus

Related to the fer-de-lance group of pit vipers by family (Crotalidae), the neotropical rattlesnake *Crotalus durissus* (Figure 2) is the only rattlesnake found south of Mexico. Ranging throughout Central and South America, it also has the widest distribution of any rattlesnake. Its local name, cascabel, is short for ‘vibora de cascabel’ or ‘vibrating rattle’. More than a dozen subspecies varying in size, pattern, color and scalation, have been recognized. It is a stocky, terrestrial snake growing to 1 m in length, although some individuals have grown to 1.6 m (5 ft). It is easily identified by its dark paravertebral stripes and is generally found in open, semi-arid forests. It is rarely encountered in dense forest or rain forest. The effects of the venom of *Crotalus durissus terrificus* in Brazil have an alleged mortality incidence of 72% in untreated cases [1].

Lachesis muta

The fer-de-lance’s largest cousin, the bushmaster (*Lachesis muta*) (Figure 3) is found in lower Central America and northern Southern America. It is readily distinguished by its strongly keeled dorsal scales; it is the largest venomous snake in the New World and the longest viper in the world. Commonly reaching lengths of from 1.8 to 2.5 m (6–8 ft), the

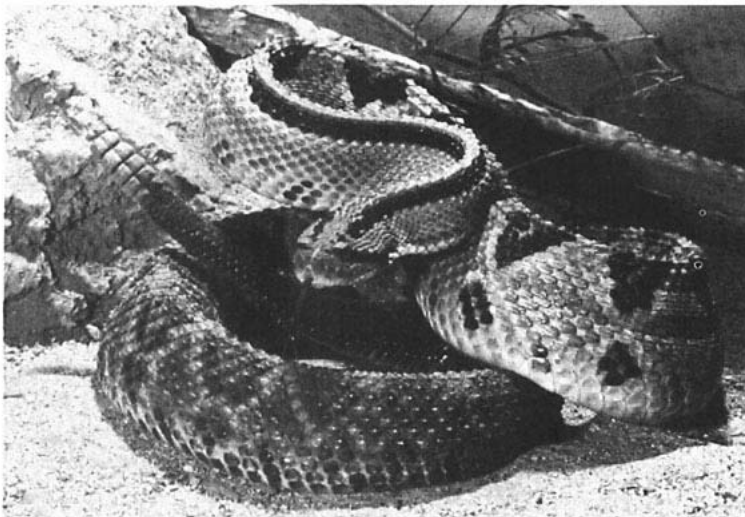


Fig. 2. *C. durissus terrificus* – the neotropical rattlesnake.

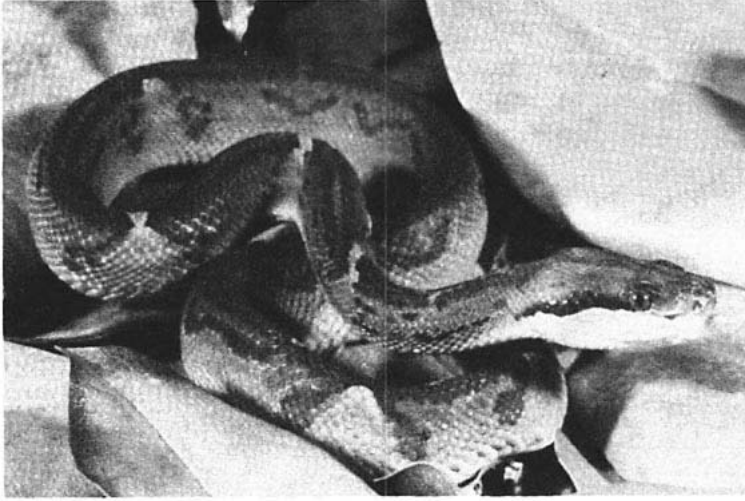


Fig. 3. *Lachesis muta* – the bushmaster.

species record is held by an individual that measured more than 3.6 m (just under 12 ft). It is the only oviparous (egg-laying) New World viper, while all others are oviviparous, or live-bearing. Because its tail terminates in a thorn-like spine instead of a rattle, its Spanish name is 'cascabela muda' or 'silent rattler'. It favors wet tropical forests, or riparian situations in drier areas. The bushmaster lives beneath fallen logs and large tree buttresses and forages at night for small animals. Although it is not frequently encountered, fatality rates as high as 80% have been recorded in Costa Rica [1, 3].

Clinical considerations

Central and South American *Crotalidae* are aggressive and dangerous snakes (Table 3) [6]. The majority of reported bites are inflicted by the genus *Bothrops*. Of these, 50% are inflicted by *Bothrops jararaca*. Eleven per cent of the bites are inflicted by *Crotalus durissus* and less than 1% by the bushmaster (*Lachesis muta*) [6]. Clark captured 12187 snakes in local Panamanian fruit plantations [7]. Of these, 24% were venomous; 80% of these belonged to the genus *Bothrops*, 4% to the genus *Lachesis*, and 16% belonged to the family *Elapidae*.

The majority of bites occur on the distal lower extremity; most envenom, but nonenvenoming (dry) bites occur. Most commonly, the venom is deposited in the skin and subcutaneous tissues. Initial local proteolytic symptoms occur within minutes and include pain and swelling. As the venom is absorbed into the lymphatic system, edema and ecchymosis progress proximally. When venom is further absorbed, systemic symptoms manifest. Cardiovascular problems include pulmonary petechiae, micro-embolism, hypotension and peripheral circulatory collapse.

The majority of venoms exhibit strong procoagulant and anticoagulant effects. They lyse fibrinogen and within hours consume prothrombin, fibrinogen and clotting factors II, V, VII, IX, X and XI, thereby producing disseminated intravascular coagulopathy. Fibrinogen and platelet levels can fall precipitously. Fibrin split products become

Table 3. Venomous snake species and frequency of bites compiled by G. Rosenfeld [6]

Species	Compiled data (1902–1945) by da Fonseca (1949)				Hospital Vital Brazil 12 years (1954–1965)			
	No. of cases	%	Deaths No.	%	No. of cases	%	Deaths No.	%
<i>Crotalus durissus terrificus</i>	738	11.38	90	12.2	143	8.32	17	11.89
<i>Bothrops sp.</i>	–	–	–	–	915	53.23	8	0.87
<i>Bothrops alternatus</i>	384	5.82	8	2.0	3	0.17	0	0
<i>Bothrops atrox</i>	83	1.26	1	1.2	–	–	–	–
<i>Bothrops cotiara</i>	96	1.45	1	1.0	1	0.058	0	0
<i>Bothrops jararaca</i>	3446	52.20	25	0.7	625	36.38	2	0.32
<i>Bothrops jararacussu</i>	657	9.95	11	1.6	14	0.82	1	7.14
<i>Porthidium (Bothrops) lansbergii</i>	1	0.015	0	0	–	–	–	–
<i>Bothrops neuwiedi</i>	236	3.58	1	0.4	2	0.12	–	–
<i>Bothrops neuwiedi paoloensis</i>	–	–	–	–	1	0.058	–	–
<i>Bothrops pradoi</i>	–	–	–	–	1	0.058	–	–
<i>Bothriechis (Bothrops) schlegelii</i>	3	0.045	1	–	–	–	–	–
<i>Lachesis muta muta</i>	16	0.24	1	6.2	–	–	–	–
<i>Micrurus corallinus</i>	–	–	–	–	1	0.058	0	0
<i>Micrurus frontalis</i>	–	–	–	–	2	0.12	0	0
<i>Micrurus lemniscatus</i>	–	–	–	–	2	0.12	0	0
<i>Micrurus sp.</i>	15	0.23	0	0	8	0.47	2	25.00
Not specified	926	14.03	22	2.3	–	–	–	–
Total	6601		161	2.43	1718		30	1.75

elevated and bleeding parameters change, as seen with other consumption coagulopathies. A recent series of 34 patients bitten by *B. jararaca* reported that 59% of victims had local and/or systemic bleeding [8].

Untreated moderate and severe envenomations invariably produce dramatic local tissue necrosis and destruction. Early deaths are caused by cardiovascular collapse, cerebral edema, internal hemorrhage and in some cases renal cortical necrosis leading to acute renal failure. Contrary to the high mortality rate reported by Campbell [1] for *C. durissus*, the overall mortality rate is relatively low, as seen in Table 3; the morbidity in untreated envenomed cases approaches 100% and is only a matter of degree [1]. Local tissue necrosis and destruction can be extensive. The resulting convalescence can be weeks to months and in moderate and severe envenomations, permanent disfigurement and disability can occur.

Prompt and appropriate treatment with the correct antivenin neutralizes the venom and prevents both local and systemic manifestations. Late antivenin treatment will interrupt the progression of symptoms and may facilitate healing.

Because there are differences between the species *Bothrops*, *Crotalus* and *Lachesis*, each will be considered separately. *Bothrops* inflicts the majority of venomous bites. Well documented case histories were not easily found. The following sketchy report typifies the course of poorly treated envenomations.

A 51-year-old male was bitten by *Bothrops atrox* 4.5 h prior to hospitalization [9]. The bite occurred on the dorsal surface of the right foot. Two puncture wounds 2.5 cm (1 in) apart were noted. Immediately following the bite, the patient experienced intense pain at the bite site. The foot and leg soon became swollen. Gingival bleeding occurred 3 h after the bite. Ultimately, an 'abscess' was noted in the area of the fang punctures. The patient was treated with one vial of polyvalent antivenin on the fourth day of hospitalization. The 'abscess' required surgical drainage on the seventh day of hospitalization. Marked sloughing around the incision followed. The patient required a total of 139 days hospitalization for recovery.

Most commonly, *Bothrops* venom is injected into the dermis and subcutaneous tissues. Dry bites can occur with all *Bothrops* species. The venom exerts an immediate local proteolytic reaction. Pain is experienced within minutes. Edema and ecchymosis ensue shortly thereafter and with significant envenomations are evident within 10–15 min.

As the tissue destruction progresses, blebs may form. These can be extremely large and measure in excess of 10 cm in diameter. The bleb fluid may be clear or serosanguine blue.

Venom is absorbed via the lymphatic system and from there gains access to the vascular system. Systemic manifestations can present as early as 20–30 min after the bite. The anti-coagulant properties of the venom are readily evident as the swollen limb becomes ecchymotic. Noncoagulating blood is common and presents with bleeding from all wounds and many orifices. Signs and symptoms of *Bothrops* envenomation are listed in Table 4.

Kerrigan reported on 294 snakebites in Eastern Ecuador [10]. Symptoms included pain in 59% of patients and swelling in 55%. Signs included edema in 87% of patients. Forty-four per cent had clinical evidence of coagulopathy with bleeding reported from the oral mucosa, urinary tract, upper gastrointestinal tract, respiratory tract and vagina. Four per cent of the patients were hypertensive and 3% were comatose. Complications including abscess, intracranial hemorrhage, tissue loss and blood loss sufficient to require transfusion occurred in 25% of patients. The mortality rate was 5.4%; 12 patients died of intracranial hemorrhage and four died of hypovolemic shock. Nishioka reported on 292 *Bothrops* bites in Brazil [11]. Fang marks were present in 58% of cases and local swelling in 85%. The clotting time exceeded 15 min in 54% of cases. Abscesses developed in 18% of cases, tissue necrosis in 16% and renal failure in 5%. Three cases required amputation and three people died, including a 33-year-old man, a 1-year-old girl and a 10-year-old-girl.

Table 4. Signs and symptoms of *Bothrops* envenomation

Pain	Gingival bleeding
Edema	Rectal bleeding
Erythema	Dizziness
Ecchymosis	Nausea
Necrosis	Vomiting
Bleb formation	Hematemesis
Cutaneous petechiae	Hematuria
Epistaxis	Regional adenopathy

Table 5. Signs and symptoms of *Crotalus durissus terrificus* envenomation

Pain	'Neurotoxic facies'
Numbness	Rhabdomyolysis
Visual disturbances	Oliguria
Ophthalmoplegia	Acute renal failure
Blepharoplegia	Coagulation abnormalities
Myalgias	Hyporeflexia
Muscle weakness	Prostration
Paresis of spinal musculature	Coma

Crotalus durissus terrificus is a dangerous, ill tempered rattlesnake. Envenomation shows little local proteolytic activity. Pain and numbness are common; edema and ecchymosis are mild and less common than with other *Crotalidae*. There is a neurotoxic component affecting the muscles of the face and spinal column. Visual disturbances, ophthalmoplegia, blepharoplegia and weak facial muscles give a rather typical appearance, described by Rosenfeld as 'neurotoxic facies' [6].

Rhabdomyolysis is particularly evident with *C. durissus* envenomation [9, 12]. Myoglobin is released into the circulation. Renal tubular necrosis ensues as evidenced by diminished urine output and acute renal failure. Table 5 lists the signs and symptoms of *C. durissus* envenomation. The following case history is exemplary [13].

A 27-year-old male was bitten in the fields near San Paulo, Brazil by a snake described as *C. durissus terrificus*. He arrived at the hospital 3 h after being bitten. Local symptoms were minimal. The patient was somnolent. Palpebral ptosis, ophthalmoplegia and myalgias were present. The blood pressure was 120/80 mm Hg. IV fluids were administered and anticrotalus serum (Butantan) was given IV, sufficient to neutralize 200 mg venom.

In spite of this, the urine decreased in volume and darkened in color. Anuria occurred after 24 h and hemodialysis was begun. Blood, urea and nitrogen and creatine were elevated. Creatine kinase, lactic dehydrogenase and aspartate aminotransferase were elevated. A muscle biopsy from the calf demonstrated rhabdomyolysis. By day 7, the patient was urinating. He was discharged from the hospital on day 28.

A rather unusual case of severe crotalid envenomation is reported from Sweden where an individual who owned six venomous snakes presented to a Swedish emergency department having been bitten by *C. durissus terrificus* [14]. He had been bitten and envenomed by another pet, a puff adder (*Bitis arietans*) 6 weeks previously. From the crotalid bite he became very ill and was comatose for one week. His hospital evaluation

Table 6. Signs and symptoms of *Lachesis muta* envenomation

Pain	Diarrhea
Edema	Abdominal colic
Ecchymosis	Hypotension
Necrosis	Bradycardia
Bleb formation	Coagulopathies

and course are superbly documented. He was treated with Wyeth polyvalent antivenin and eventually recovered.

Renal failure secondary to tubular necrosis is well known with *C. durissus* envenomation. Dark urine and a positive benzidine test are common. Jaundice, anuria and hematuria are strikingly absent. Azevedo-Marques, Hering and Cupo in 1987 reviewed the subject and reported three interesting cases from Brazil. They concluded that the venom causes myolysis, not hemolysis [13]. The same authors reported on ten children envenomed by *C. durissus* [12]. They reaffirmed that the major actions of *C. durissus* venom in humans are neurotoxic and myotoxic.

In addition to local pain, swelling, tissue necrosis and coagulopathies, *Lachesis* envenomation causes more distinct cardiovascular and abdominal symptoms. These include bradycardia, cardiac arrhythmias and intense abdominal colic and bloody diarrhea. The signs and symptoms of *Lachesis muta* envenomation are listed in Table 6. The following case history is presented to demonstrate the common hematologic effects and to distinguish the *Lachesis* bite from that seen with *Bothrops* and *Crotalus*.

A 42-year-old male arrived at a Brazilian emergency department 15 min after receiving a bite from a *Lachesis* on the left distal anterior aspect of the forearm [15]. On arrival, the patient complained of intense pain at the bite site. Blood oozed through the fang punctures. The patient complained of intense abdominal colic and had profuse diarrhea. His systolic blood pressure was 50 mm Hg and his heart rate was 50 beats per min.

On examination, the patient was pale with weak peripheral pulses. He was dizzy and vision was blurred. Heart sounds were distant and the abdominal exam revealed increased bowel sounds. The edema had already progressed to mid forearm. The patient was treated with 30 vials of Bothropico Butantan antivenin (Brazil). The patient was given atropine for his colic and epinephrine for low blood pressure. He was hydrated intravenously. The edema extended to involve the entire arm 3 h later. Serous vesicles were reported on the bitten arm 4 h after envenomation. Following an infusion of antivenin, blood pressure returned to normal. The abdominal colic dissipated and the swelling ceased its progression.

The edema and vesicles on the bitten extremity were nearly gone by hospital day 7 and the patient was discharged on day 14.

Before discussing the first aid and medical management of Central and South American *Crotalidae*, one needs to think about the available antivenins. The most easily obtained in the US is produced by Wyeth and is a polyvalent antivenin. This antivenin is raised in horses, as are most antivenins, and is induced from a selection of North and South American pit viper venoms, most commonly *C. adamanteus*, *C. atrox*, *C. durissus* and *B. atrox*. It is effective against all South American pit vipers [16, 17]. Theakston and Warrell list 46 antivenins for American snakes, 38 of which cover South American pit vipers, some monovalent species specific and some polyvalent in their coverage [18]. Their list of antivenins makes no attempt to grade the quality of the antivenins. The appropriate section of this publication is reproduced in Table 7.

Generally speaking, assuming availability, it is advisable to use the antivenin made in an area in which the snake is indigenous. Fortunately, all of the antivenins cross react, and so one can use whatever is available. If one is traveling from the US, the Wyeth polyvalent antivenin is available, consistent and effective.

It is difficult to determine the number of vials of antivenin necessary to treat a bite. It

Table 7. Antivenins for American snakes

Antidote	Source	Venoms covered	Specific name	Treatment/ other data
Wyeth antivenin (Crotalidae) polyvalent (E)	Wyeth-Ayerst Laboratories, PO Box 8299, Philadelphia, PA 19101-1245, USA Phone: (215) 688-4400 or Wyeth Laboratories Inc. Marietta, PA 17547, USA Phone: as above	Eastern diamondback rattlesnake, Western diamondback rattlesnake, Tropical rattlesnake Barba amarilla	<i>Crotalus adamanteus</i> <i>C. atrox</i> <i>C. durissus terrificus</i> <i>Bothrops atrox</i>	iv D – 10 ml AS-PD (Also neutralizes other <i>Crotalus</i> , <i>Sistrurus</i> , <i>Agkistrodon</i> , <i>Bothrops</i> , <i>Lachesis</i> and <i>Trimeresurus</i> spp.) Validity 5 years
Antivenin (<i>Micrurus fulvius</i>) (equine origin) North American coral snake antivenin (E)	As above	Eastern coral snake	<i>Micrurus f. fulvius</i> [< 20] [N. America]	iv D – 10 ml AS-PD <i>M. f. tenere</i> Validity 5 years US\$144 RID 3.5 vials
Snake antivenin (S)	Laboratories 'MYN' SA, Av. Coyoacan 1707, Mexico 12 DF Mexico	Barba amarilla, Jumping viper, Western diamondback rattlesnake, Black rattlesnake, Tiger rattlesnake, Cascavel, Yucatan neotropical rattlesnake, Cantil	<i>B. asper</i> <i>B. nummifera</i> <i>C. atrox</i> <i>C. molossus nigrescens</i> <i>C. tigris</i> <i>C. d. durissus</i> <i>C. d. tzabcan</i> <i>Agkistrodon bilineatus</i>	iv D – 10 ml (Also neutralizes all Mexican crotalids) Validity 5 years
Monovalent <i>Bothrops</i> (S)	As above	Barba amarilla	<i>B. atrox asper</i>	iv NI
Polyvalent <i>Crotalus</i> (S)	As above	Western diamondback rattlesnake, Cascavel, Tiger rattlesnake	<i>C. atrox</i> <i>C. d. terrificus</i> <i>C. tigris</i>	iv NI
Polyvalent Mexico (S)	As above	Barba amarilla, Cascavel, Tiger	<i>B. atrox asper</i> <i>C. d. terrificus</i>	iv NI

Table 7. continued.

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
		rattlesnake, Western diamondback rattlesnake	<i>C. tigris</i> <i>C. atrox</i>	
Anti- <i>Crotalus</i> (S)	Gerencia General de Biologicos y Reactivos, Secretaria de Salud, Amores 1240, Colonia del Valle, Mexico 03110, DF, Mexico Phone: 575-9155 Telex: 1764004 GGBR ME	NI	NI	iv NI (Neutralizes all Mexican <i>Crotalus</i>)
Anti- <i>Bothrops</i> (S)	As above	NI	NI	iv NI (Neutralizes all Mexican <i>Bothrops</i>)
Suero antiofidico export lyophilized (E)	Grupo Pharma, SA de CV, Zapata Labs, Mexico City, Mexico Phone: 592-82-70, 561-12-11, 592-88-93	Cascavel, Barba amarilla	<i>C. d. terrificus</i> <i>B. atrox</i> [21-50] [Sinaloa, Nayarit, Jalisco, Colima, Sonora, Taumaulipas, Durango, Veracruz, Tabasco, Quintana Roo, Chihuahua, Campeche, Chiapas, States]	iv/im D - 10 ml AS-PD Electrophoresis. Other <i>Bothrops</i> spp. All Mexican and Central and South American <i>Bothrops</i> and <i>Crotalus</i> one vial neutralizes 880 LD ₅₀ ml ⁻¹ <i>Bothrops</i> and 240 LD ₅₀ ml ⁻¹ <i>Crotalus</i> venom. Validity 5 years
Anticoral (polyvalent) (S)	Instituto Clodomiro Picado, Universidad de	Black-banded coral snake, North American coral snake, Dumeril's	<i>M.</i> <i>nigrocinctus</i> <i>M. f. fulvius</i>	iv D - 10 ml AS

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
	Costa Rica Ciudad Universitaria, Rodrigo Facio, San Jose, Costa Rica Telex: UNICORI 2544	coral snake	<i>M. carinicauda</i>	
Polyvalent antivenom (S)	As above	Cascavel, Bushmaster, Barba amarilla	<i>C. d. durissus</i> <i>Lachesis muta</i> <i>stenophrys</i> <i>B. asper</i> [> 100] [<i>C. d. durissus</i> Costa Rica, Pacific; <i>L. m.</i> <i>stenophrys</i> Costa Rica, Atlantic; <i>B.</i> <i>asper</i> Costa Rica, Atlantic + Pacific]	iv/im L - 10 ml/D - 10 ml AS Horse or sheep serum <i>B. atrox</i> , <i>B. schlegelii</i> , <i>B. nummifer</i> , <i>B. lateralis</i> , <i>B. godman</i> , <i>B. nasutus</i> , <i>B. ophyromegas</i> , <i>B. nigroviridis</i> , <i>A. bilineatus</i> (Also most pit vipers from South America) Validity L - 3 years, D - 5 years L - US\$10; D - US\$12 RID 50 ml
Panamerican serum: anticoral polyvalent serum (S)	As above	North American coral snake, Black-banded coral snake, Dumeril's coral snake, Brazilian giant coral snake, Brazilian coral snake, ? Black-ringed coral snake, Allen's coral snake ?	<i>M. fulvius</i> <i>M.</i> <i>nigrocinctus</i> <i>M. carinicauda</i> <i>M. frontalis</i> <i>M. corallinus</i> <i>M. spixii</i> <i>M. mipartitus</i> <i>M. alleni</i> <i>M. lemniscatus</i>	iv D - 10 ml

Table 7. continued.

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
Anticoral (monovalent) (S)	As above	Black-banded coral snake	<i>M. nigrocinctus</i> [> 100] [Costa Rica, Atlantic and Pacific]	iv/im L - 10 ml/D - 10 ml AS Also <i>M. fulvius</i> , <i>M. carinacauda</i> Validity L - 3 years, D - 5 years US\$15 RID 40 ml
Anti-Laquesico (S)	As above	Bushmaster	<i>L. muta</i>	iv As above
Anti- <i>Bothrops</i> (S)	Instituto Nacional de Higiene y Medicina Tropical 'Leopoldo Izquieta Perez' Casilla Postal 3961, Guayaquil, Ecuador	Barba amarilla	<i>B. asper</i>	iv L - 10 ml AS
Antiophidico polyvalente (S)	Instituto Nacional de Salud, Av. Eldorado con Carrera, Zona G, Bogota DE, Colombia Phone: 5712220577	Barba amarilla, Cascavel	<i>B. asper</i> <i>C. d. terrificus</i>	iv L - 10 ml AS
Anticrotalic (P)	Instituto Butantan, Av. Vital Brazil, Caixa Postal 65, Sao Paulo-SP, Brazil Phone: (011)813 7222 Fax: (011) 815 1505 Telex: 11-83325 BUTA BR	Cascavel	<i>C. d. terrificus</i>	iv L - 10 ml AS-PD

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
Antilaquetico (P)	As above	Bushmaster	<i>Lachesis muta</i>	iv L – 10 ml AS-PD
Antibotropico (P)	As above	Jararaca, Moojen's viper, Cotiara, Urutu, Jararacussu, Jararaca pintada	<i>B. jararaca</i> <i>B. joojeni</i> <i>B. cotiara</i> <i>B. alternatus</i> <i>B. jararacussu</i> <i>B. neuwiedi</i>	iv L – 10 ml AS-PD Following venoms used for immunization: <i>B. jararaca</i> 50% <i>B. jararacussu</i> 8.25% <i>B. alternatus</i> 8.25% <i>B. moojeni</i> 8.25% <i>B. neuwiedi</i> 8.25% <i>B. cotiara</i> 8.25% <i>B. pradoi</i> 8.25%
Antiophidico polyvalent (P)	As above	Cascavel, Jararaca, Moojen's viper, Cotiara, Urutu, Jararacussu, Jararaca pintada	<i>C. d. terrificus</i> <i>B. jararaca</i> <i>B. moojeni</i> <i>B. cotiara</i> <i>B. alternatus</i> <i>B. jararacussu</i> <i>B. neuwiedi</i>	iv L – 10 ml AS-PD
Antibotropico laquetico (P)	As above	Bushmaster, Urutu, Jararacussu, Jararaca, Moojen's viper, Cotiara, Jararaca pintada	<i>L. muta</i> <i>B. alternatus</i> <i>B. jararacussu</i> <i>B. jararaca</i> <i>B. moojeni</i> <i>B. cotiara</i> <i>B. neuwiedi</i>	iv L – 10 ml AS-PD
Antielapidico (P)	As above	Giant coral snake, Brazilian coral snake	<i>M. frontalis</i> <i>M. corallinus</i>	iv L – 10 ml AS-PD
Soro antibotropico (P)	Instituto Vital Brazil SA, Caixa Postal 28, Niteroi, Rio de Janeiro, Brazil Phone: 55212558688	Jararaca, Jararacussu, Urutu, Moojen's pit viper Jararaca ? Cotiara	<i>B. jararaca</i> <i>B. jararacussu</i> <i>B. alternatus</i> <i>B. moojeni</i> <i>B. neuwiedi</i> <i>B. pradoi</i> <i>B. cotiara</i>	iv L – 10 ml AS-PD (25 mg venom neutralized per 10 ml) Following venoms used for immunization: <i>B. jararaca</i> 50% <i>B. jararacussu</i> 25% <i>B. alternatus</i> 5%

Table 7. continued.

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
				<i>B. moojeni</i> 10% <i>B. neuwiedi</i> 10%
Soro anticrotalico (P)	As above	Cascavel	<i>C. d. terrificus</i>	iv L - 10 ml (10 mg venom neutralized per 10 ml)
Soro antiofidico polyvalente (P)	As above		<i>Bothrops</i> spp. <i>Crotalus</i> spp.	iv L - 10 ml (25 mg <i>Bothrops</i> venom neutralized per 10 ml; 10 mg <i>Crotalus</i> venom neutralized per 10 ml)
Antibotropico (P)	Fundacao Ezequiel Dias, Rua Conde Pereira Carneiro 80, 30500 Belo Horizonte, Brazil Phone: (031)332-2077 Fax: (031)332-2534 Telex: 392417 FEDS BR	Jararaca, Jararacussu, Urutu, Moojen's viper, Jararaca pintada	<i>B. jararaca</i> <i>B. jararacussu</i> <i>B. alternatus</i> <i>B. moojeni</i> <i>B. neuwiedi</i>	iv L - 10 ml AS-PD 25 mg neutralized per ampoule. Following venoms used for immunization: <i>B. jararaca</i> 50% <i>B. jararacussu</i> 12.5% <i>B. alternatus</i> 12.5% <i>B. atrox</i> or <i>B. moojeni</i> 12.5% <i>B. neuwiedi</i> 12.5%
Anticrotalico (P)	As above	Cascavel	<i>C. d. terrificus</i>	As above, 10 mg per amp. neutralized
Antibotropico crotalico (P)	As above	Cascavel, <i>Bothrops</i> spp.	<i>C. d. terrificus</i> <i>Bothrops</i> spp.	As above, 20 mg <i>B. atrox</i> and 10 mg <i>C. d. terrificus</i> neutralized per ampoule
Antibotropico laquetico	As above	Barba amarilla, Bushmaster	<i>B. atrox</i> <i>L. muta</i>	As above
Suero antibotropico	Institutos Nacionales de	Barba amarilla, Sururucucu de	<i>B. atrox</i> <i>B. bilineatus</i>	iv NI

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
polyvalente (S)	Salud, Departamento de Animales Venenosos, Calle Capac Yupanqui no 1400, Apartado no 451, Lima, Peru Phone: 5114416141, 5114678212, 5114311130	patioba, Castelnau's pit viper, Brazil's pit viper ?	<i>smaragdinus</i> <i>B. castelnaudi</i> <i>B. brazili</i> <i>B. pictus</i>	
Suero antilachesico (S)	As above	Bushmaster	<i>L. muta</i>	As above
Suero anticrotálico (S)	As above	Cascavel	<i>C. d. terrificus</i>	As above
Bothrops polyvalente (S)	Instituto Nacional de Higiene, Lima, Peru	Barba amarilla, <i>Bothrops</i> spp., Bushmaster	<i>B. atros asper</i> <i>Bothrops</i> spp. <i>L. muta</i>	iv D-? ml purified
Anti-coral polyvalente (S)	As above	Black-banded coral snake, Northern coral snake, Giant coral snake	<i>M. nigrocinctus</i> <i>M. miparitus</i> <i>M. frontalis</i>	iv As above
Suero antilachesico (S)	As above	Bushmaster	<i>L. muta</i>	iv NI
Suero anticrotálico (S)	As above	Cascavel	<i>C. d. terrificus</i>	iv NI
Antibothrops bivalente (S)	Instituto Nacional de Microbiología, 'Dr Carlos G. Malbran', Av. Velez Sarsfield 563, Buenos Aires, Argentina	Yarara, Wied's lance-head, Yarara nata	<i>B. alternatus</i> <i>B. neuwiedi</i> <i>diporus</i> <i>B. ammodytoides</i>	iv L - 10 ml (Purified by enzymatic and differential thermo- coagulation)
Antibothrops tetraivalente (S)	As above	Yarara, Wied's	<i>B. alternatus</i> <i>B. neuwiedi</i>	iv As above

Table 7. continued.

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
		lance-head, Jararaca, Jararacussu	<i>B. jararaca</i> <i>B. jararacussu</i>	
Anticrotalus (S)	As above	Cascavel	<i>C. d. terrificus</i>	iv As above
Antimicrurus (S)	As above	Giant coral snake, Brazilian coral snake	<i>M. frontalis</i> <i>M. corallinus</i>	iv As above
Tropical trivalente (S)	As above	Yarara, Wied's lance-head, Cascavel	<i>B. alternatus</i> <i>B. neuwiedi</i> <i>C. d. terrificus</i>	iv As above
Antibothrops bivalente (S)	Ejercito Argentino, Campo de Mayo, Batallon 601, Pcia de Buenos Aires, Argentina	Lance-headed vipers	<i>Bothrops</i> spp.	iv D - ? ml
Antimicrurus (S)	As above	Coral snakes	<i>Micrurus</i> spp.	iv As above
Suero antiofidico polyvalente UCV (S)	Universidad Central de Venezuela, Caracas, Venezuela Phone: 582719450, 582521984, 582524719, 582525579	? Cascabel	<i>B. colombiensis</i> <i>C. d.</i> <i>cumanensis</i>	iv L - ? ml Purified equine globulins (20 mg <i>B. columbiensis</i> and 15 mg <i>C. d.</i> <i>cumanensis</i> neutralized/vial)
Anti- <i>Bothrops</i> (S)	Laboratorios Veterinarios, Instituto Nacional de Higiene, Casilla Postal 5584, Guayaquil, Ecuador	Barba amarilla <i>Fer-de-lance</i> ?	<i>B. atrox</i> <i>B. asper</i> <i>B. xanthogrammus</i>	iv L - 10 ml AS-PD 3 mg of each neutralized by 1 ml antivenom. <i>B. nasutus</i> , <i>B. castelnaudi</i> , <i>B. schlegelii</i> , <i>B. bilineatus</i> venoms also neutralized

<i>Antidote</i>	<i>Source</i>	<i>Venoms covered</i>	<i>Specific name</i>	<i>Treatment/ other data</i>
Suero antiofidico bivalente antioftropico (S)	Instituto do Higiene, Calle Alfredo Navarro 3051, Montevideo, Uruguay Phone: (598 2) 471288	Yarara, Wied's lance-head	<i>B. alternatus</i> <i>B. neuwiedi</i>	iv L – 10 ml NI purification 10 mg ml ⁻¹ used for immunization (50% of each venom) 10 mg ml ⁻¹ <i>B. alternatus</i> 1.5 mg ml ⁻¹ <i>B. neuwiedi</i> venoms neutralized. US\$2. One per vial RID four vials to be repeated according to clinical signs.

E = English; P = Portuguese; S = Spanish; AS = salt precipitated; D = lyophilized final product; ED⁵⁰ = median effective dose or median effective dose of antivenom; im = intramuscular injection; iv = intravenous injection; L = liquid final product; LD₅₀ = median lethal dose or median lethal dose of venom; (M) = monovalent (or monospecific) antivenom; MHD = minimum haemorrhagic dose or minimum haemorrhagic dose of venom; MLD = minimum lethal dose or minimum lethal dose of venom; NI = no information available; (P) = polyvalent (or polyspecific) antivenom; PD = pepsin digested; RID = recommended initial dose; sc = subcutaneous injection

depends upon the victim, snake, amount of venom injected and available antivenin. All antivenin is administered intravenously. Antivenin infusion is titrated against signs and symptoms of envenomation. Wyeth Crotalidae antivenin is infused at a rate of one vial every 7 to 10 min. One should anticipate using 10 to 20 vials for the 'average' bite, with a range of 5 to 60 vials for mild to severe envenomations. Describing the Costa Rican antivenin, Dr. Gutierrez wrote,

'Regarding the number of vials per treatment, we are recommending an initial dose of five to ten vials, depending on the absence or presence of systemic effects, five vials in cases having only local effects. Depending on the evolution of the case, it might be necessary to use five or ten additional vials. Thus, the clinical evaluation of each case is being used to define the number of vials to be administered. In the case of coral snake envenomations, we recommend an initial dose of five vials' [19].

Those interested in further clinical and investigative information are referred to the Species Index for Toxicon, Volumes 1–27, which lists 627 references for *Bothrops* species, 302 for *C. durrisus* species and 68 for *Lachesis* species [20].

Past research has focused on isolating individual proteins, enzymes and other venom ingredients active in envenomation. Because venom is a complex mixture and because there is variation between snakes, past research has focused to a considerable extent on analysis of the active components of venoms and on improved antivenin production.

Some of the protein components of venoms have been isolated and sequenced by molecular biologic techniques. Nepper and Jacobson [21] isolated a complementary DNA (cDNA) from the mRNA of the venom glands of another member of the *Crotalidae* family, *Trimeresurus gramineus*. This cDNA includes within its 2017 nucleotide sequence an open reading frame of 1146 nucleotides, thus potentially coding for a protein length of 488 amino acids. Embedded within this is a sequence for the 72 amino acid mature trigramin protein, which by sequence homology appears to be a member of the disintegrin family of platelet aggregation inhibitors. In a more extensive analysis of the cDNA sequence, Kini and Evans [22] have translated the full open reading frame of the cDNA and aligned it with that of a number of other venom proteins for which sequences have been directly determined. They discovered that these proteins all contain: (a) sequences of members of the metalloproteinase family, (b) sequences of members of the nonenzymatic disintegrin platelet aggregation inhibiting family and (c) other mutually homologous sequences of unknown function(s). They proposed that the components of venom are derived by proteolytic processing of a long precursor protein (which as expected includes a signal peptide for secretion at its amino terminus). Based on experience in other fields, we may anticipate that in the future the molecular biologic approach will be an effective way to identify the complex composition of venoms and may provide purified antigens for antivenin production.

First aid

In the event of an actual or probable bite from a Central or South American *Bothrops*, *Crotalus* or *Lachesis*, execute the following first aid measures.

- (1) Make sure that the responsible snake has been appropriately and safely separated from the victim and other humans and cannot inflict another bite. Killing the snake and/or bringing it to the hospital is not necessary. Correct identification is always useful.
- (2) Immediately transport the victim to an appropriate medical facility.
- (3) Keep the victim calm, supine or prone with as little movement as possible. Rest the bitten limb at a level lower than the victim's heart. Remove constricting jewelry.
- (4) Place a constricting band around the extremity proximal to the bite. A 1" wide × 18" long penrose drain is an excellent constricting band. Distal arterial pulses should not be impeded.
- (5) Incision and suction is not indicated.
Electroshock is not indicated [23].
Do not incise the bite site.
Do not apply ice to the bite.
- (6) If available, carry Wyeth *Crotalidae* Polyvalent antivenin (20–40 vials) with the victim to the hospital. The Costa Rican and Butantan antivenin are also effective; other antivenins are available, but their effectiveness is unknown to the authors. If antivenin is not available, contact a Regional Poison Control Center in the US, or one of the antivenin producers in South America.

Medical management

- (1) A constricting band has been applied to retard the absorption of venom. Do not remove this constricting band until the patient has arrived at the hospital and is receiving antivenin.
- (2) Make sure that appropriate antivenin is available. If you need assistance in locating appropriate antivenin, contact a Regional Poison Control Center in the US. The San Diego Regional Poison Control Center telephone number is (619) 543-6000.
- (3) Envenomation is diagnosed by the presence of characteristic signs and symptoms (see Tables 4–6). Local pain and swelling are often the first indications of envenomation. Progression of swelling, bleeding from the fang mark(s) and other sites, echymosis and bleb formation are also common symptoms. They may appear early or not until several hours after the bite.

Cardiovascular and hematologic symptoms tend to occur only after a certain volume of venom has been absorbed. They may occur early in the bite, as soon as 0.5 h or later, even 12–24 h after the bite. Hypotension is seen with severe bites.

Fang marks may be present as one or more well defined punctures, as a series of small lacerations or scratches, or may be absent. Absence of fang marks does not preclude the possibility of a bite, especially if a juvenile snake is involved. Conversely, the fang marks do not always confirm envenomation.

- (4) Admit the patient to an intensive care setting. Begin a peripheral IV infusion of lactated Ringer's solution at a rate sufficient to induce and maintain a brisk urine output. Because of rhabdomyolysis and acute renal failure seen with *Lachesis* envenomation, a brisk diuresis is crucial.

Children and individuals with compromised cardiovascular or renal function may not tolerate a fluid challenge without invasive monitoring to allow judicious administration of osmotic or loop diuretics.

- (5) Draw blood samples from the contralateral arm to obtain the laboratory tests listed in Table 8. It may be necessary to repeat some tests during the hospital course to monitor the effects of antivenin therapy.
- (6) Observe the patient closely for signs and symptoms of envenomation. If no sign or symptom is noted, it is possible that the patient received a 'dry' bite (no venom injected).

Remove the constricting band and observe carefully for any change in the patient's status. If signs and symptoms still fail to manifest, continue close observation for an additional 24 h. Should a change occur, assume the patient has been envenomed, and prepare to give antivenin.

- (7) If more than mild signs or symptoms become apparent, begin antivenin therapy. The majority of antivenin is prepared in horses; individuals allergic to horse serum may be allergic to the antivenin. Anaphylaxis can occur. The following are our recommendations for the Wyeth Crotalidae antivenin. The principles are the same for other products. The doses will be different and you are strongly encouraged to obtain assistance and advice from local medical sources. For individuals in whom antivenin therapy is indicated, a skin test with 0.1 cc of horse serum (provided in the antivenin kit) is injected intradermally. Observe for a period of 20 min. If no reaction occurs, administer the antivenin. If a cutaneous reaction occurs, antivenin can still be administered. There is an increased risk of anaphylaxis and the treating physician

Table 8. Laboratory tests recommended in the evaluation of *Crotalidae* envenomation

CBC with differential and platelet count.

Coagulation Parameters:

- a. Prothrombin Time (PT)
- b. Partial Thromboplastin Time (PTT)
- c. Fibrinogen levels
- d. Fibrin degradation products

Serum electrolytes, BUN/creatinine, calcium, phosphorus, lactate dehydrogenase (with isoenzyme analysis)

Urinalysis

Electrocardiogram

must be prepared. For further information, the reader is referred to past articles in the *Journal of Wilderness Medicine* (24–26). The Wyeth antivenins are weak and need to be given liberally. They are administered in five vial aliquots. Each vial is reconstituted by mixing 10 cc of diluent or lactated Ringer's with the lyophilized antivenin. The antivenin is reconstituted by shaking. This can be facilitated by using room temperature or even slightly warmed diluents.

The five vials are drawn up and constitute a total volume of 50 cc. These are administered IV piggyback with the lactated Ringer's solution. The antivenin is administered at a rate of one vial every 10 min (1 cc per min). If this is tolerated, the infusion rate can be increased to one vial every 7–10 min. The five vials of antivenin are administered over the ensuing 30–60 min. Remove the constricting band after two vials have been infused.

- (8) Additional antivenin is administered in five vial aliquots. Additional antivenin is indicated when symptoms such as pain, muscle fasciculation, tingling, vomiting and ophthalmoplegia occur. It is also indicated when other signs or symptoms such as swelling, ecchymosis or bleb formation are progressive. One should anticipate using 10–20 vials of antivenin, for the average bite. For severe envenomation, as many as 60 vials may be required.
- (9) Should any sign(s) of allergy or anaphylaxis develop, discontinue the antivenin administration immediately and treat the victim with epinephrine, steroids and antihistamines. As soon as the patient is stabilized, continue the antivenin infusion at a slower rate. Simultaneous infusion of epinephrine may be necessary.
- (10) If breathing becomes impaired, provide respiratory assistance. Supplemental oxygen is advised. Disseminated intravascular coagulopathy is rarely an early sign and normally occurs only when insufficient antivenin is administered or when the antivenin is administered several hours after the bite.
- (11) It is important to keep venom neutralization continuous. Keep a close watch on the patient's status. If the victim's condition worsens, additional antivenin should be administered in five vial aliquots.

General considerations

Cardiovascular or systemic symptoms normally only occur early in a severe envenomation. If these occur during treatment, either the patient is experiencing an allergic response or the bite is being grossly undertreated.

Coagulation problems occur as the venom is systemically absorbed. Typically, they present when venom neutralization has not been prompt. In such cases, antivenin therapy must be administered aggressively and the coagulation problems treated as in other consumption coagulopathies. Platelet replacement is the most common requirement. Other factors and fresh plasma are only required in severe cases, particularly when treatment was initiated hours to days after the bite and coagulation factors have been consumed and depleted.

Narcotics are contraindicated because they suppress respiration. Circulatory shock uncorrected by antivenin therapy requires plasma volume expanders and/or vasopressor agents.

Tetanus prophylaxis should be current. Prophylactic antibiotics are not recommended.

Follow-up care

Once venom neutralization is complete, the patient should be admitted to the hospital and observed in an appropriate setting for a minimum of 24 h. In most cases this would be in an intensive care unit. If the patient is watched on the ward, continuous monitoring is required. Vital signs should be observed frequently until they are stable.

Approximately one third of the patients who receive five or more vials of Wyeth antivenin will develop a delayed allergic response. This normally manifests between 7 and 21 days, most commonly as a cutaneous reaction. Normally this is treated with antihistamines, but occasionally systemic steroids will be required.

Compartment syndromes are exceedingly rare. Early surgical debridement and or fasciotomy is rarely if ever indicated. Should a compartment syndrome be suspected this must be documented by Wick pressure recordings. It is common to see significant swelling and elevated subcutaneous pressures, but true compartment tissue pressure elevations above 30 or 40 mm Hg are exceedingly uncommon.

Acknowledgement

We thank Dr Norman Davidson, Professor of Chemistry, Cal Tech for the molecular biology interpretation.

All figures are included with permission from the San Diego Zoo.

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