# Medically Important Venomous Animals: Biology, Prevention, First Aid, and Clinical Management

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**Venomous animals are a significant health problem for rural populations in many parts of the world. Given the current level of the international mobility of individuals and the inquisitiveness of travelers, clinicians and travel clinics need to be able to give advice on the prevention, first aid, and clinical management of envenoming. Health professionals often feel overwhelmed by the taxonomy of venomous animals; however, venomous animals can be grouped, using a simple set of criteria, into cnidarians, venomous fish, sea snakes, scorpions, spiders, hymenoterans, and venomous terrestrial snakes. Geographic distribution, habitats, and circumstances of accidents further reduce the range of culprits that need to be considered in any single event. Clinical management of envenomed patients relies on supportive therapy and, if available, specific antivenoms. Supplies of life-saving antivenoms are scarce, and this scarcity particularly affects rural populations in resource-poor settings. Travel clinics and hospitals in highly industrialized areas predominantly see patients with injuries caused by accidents involving marine animals: in particular, stings by venomous fish and skin damage caused by jellyfish. However, globally, terrestrial venomous snakes are the most important group of venomous animals.**

The medically important venomous animals consist of 6 major groups: cnidarians, venomous fish, sea snakes, scorpions, spiders, hymenopterans, and venomous terrestrial snakes. An animal is classified as venomous if it possesses a special apparatus for injecting venom. Toxic liquids delivered through special teeth, stings, arrows, nematocysts, or hairs are used to fulfill essential biological needs, such as self defense or catching prey. Unlike venomous animals, animals classified as poisonous lack an injection device. Rather, they possess toxins that are dispersed in their body tissues and that are activated when the animal is ingested [1–5].

## SOURCES OF INFORMATION

Our detailed, regularly updated database of the biology, epidemiology, prevention, first aid, and supportive and specific antivenom treatment of animal envenoming and poisoning formed the basis of this review. Personal contacts contributed substantially to our database, because most clinical experience is gathered in remote areas and is not published.

## DIVERSITY AND CLASSIFICATION OF VENOMOUS AND POISONOUS ANIMALS

To assist clinicians in assessing envenomed patients, it is important to provide a classification system that takes into consideration a clinician's limited knowledge of the biology and taxonomy of venomous and poisonous animals and the fact that, in most instances, the culprit has not been reliably observed by patients and bystanders and is not available for identification. Geographic distribution, habitat, behavior, and evolving clinical features help to delineate the culprit in the absence of direct evidence. These efforts are guided by a central question: is a venom implicated for which a specific antivenom is available?

Grouping venomous animals using a simple set of criteria (figure 1) substantially reduces the number of species that have to be considered in an envenoming incident. Subdividing venomous snakes—by far the largest and clinically most important group—into regional groups further reduces the number of species to be considered in an individual case (table 1).

| Venemous/poisonous animals of medical importance | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|

**Figure 1.** Grouping venomous and poisonous animals with a simple set of criteria

## VENOMS, POISONS, AND THEIR CLINICAL EFFECTS

Venoms are complex mixtures of species, subspecies, or even geographic-variant–specific substances that are pharmacologically highly active and can cause a wide range of clinical signs and symptoms. Venom effects are predominantly species-specific, which makes it difficult to transfer observations from animals to humans. The wide range of signs and symptoms of envenoming in humans are grouped into 7 classes: local, autopharmacological, antihemostatic, neurological, muscular, cardiac, and renal effects.

## MEDICALLY IMPORTANT VENOMOUS ANIMALS

### Cnidarians

*Biology.* A large number of coelenterate species (e.g., jellyfish, anemones, and corals) use highly efficient venom application devices—so-called nematocysts—for hunting and self-defense. When contact is made with trigger hairs, nematocysts explode and send out harpoons that penetrate the surface of the attacked organism, tracking venom-filled tubes into tissue, wherein the venom is released [4, 5].

*Clinical features.* Corals, anemones, and most jellyfish cause local irritation of the skin (e.g., burning sensations and erythema). Many tourists to the Mediterranean Sea experience this when they are stung by the jellyfish *Pelagia noctiluca* (figure 2A–2C) [6]. Episodes of flare-up reactions can also occur (figure 2C) [7, 8]. A number of jellyfish species, however, induce systemic envenoming in addition to producing massive local effects on the skin, including necrosis (figure 2D, F, and G). Such accidents have been reported in the Pacific Ocean and the Caribbean Sea (caused by box jellyfishes) and in the Atlantic and Indopacific oceans (caused by the Portuguese man o' war). Since systematic reporting was initiated in Australia in the first half of the 20th century, ~70 deaths have been attributed to the sea wasp *Chironex fleckeri* alone (figure 2F) after experiencing a massive nematocyst discharge, death of the individual may ensue within minutes. In tropical Australia, the Irukandji *(Carukia barnesi),* a box jellyfish the size of a human thumb (figure 2H), causes the Irukandji syndrome, which is accompanied by catecholamine release. Persons who experience sea-bathers' eruption (caused by sea lice *[Linuche unguiculata])* present to clinics with features that can be puzzling to those who have never come across such skin eruptions (figure 2, E). All cnidarians may cause type I hypersensitivity reactions after repeated exposure, which includes anaphylactic shock [4, 5, 9–13].

*Prevention and first aid.* Where dangerous jellyfish are suspected, one should never swim or dive unprotected; so-called stinger suits are fully protective. Universally effective and safe first aid measures for the treatment of jellyfish stings are not available. However, vinegar has been found to be very effective in deactivating the nematocysts of box jellyfish and is widely recommended and used in Australia [14], where it is available in containers at beaches. However, vinegar is ineffective against stings by the Pacific Portuguese man o' war, and it can even activate the nematocysts of the Atlantic variety of the same genus. The rapid onset and severe course of envenoming poses almost unsolvable problems in providing timely life-saving support in the event of an encounter with dangerous jellyfish. Paramedical workers have been trained to apply antivenom on site.

*Clinical management.* Patients with local envenoming require pain control and wound management, including tetanus prophylaxis if the skin is broken. In the case of severe systemic envenoming, treatment is mostly symptomatic, aiming to maintain respiration and blood circulation. Respiratory support and cardiac massage should never be stopped prematurely, because the toxins in jellyfish venom are heat labile; in fact, good outcomes have been reported after prolonged periods of resuscitation. Specific antivenom is available only for individuals who

**Table 1. Medically important venomous snakes and their geographic distribution.**

| Geographic region | Colubridae family | Elapidae family | Viperidae family | | |
| --- | --- | --- | --- | --- | --- |
| | | | Viperinae subfamily | Crotalinae subfamily | |
| Near and Middle East, North Africa | ... | Cobras (Naja species; e.g., Egyptian cobra) | Vipera species (e.g., Palestine viper and Bitis arietans [puff adder]), Echis species (e.g., saw-scaled viper), and Cerastes species (e.g., African desert horned viper) | Rarely present in the region | |
| Sub-Saharan Africa | Boomslang (Dispholidus typus) | Cobras (Naja species; e.g., black-necked spitting cobra), mambas (Dendroaspis species; e.g., black and green mamba) | Bitis species (e.g., Gabonviper and puff adder) | ... | |
| Southeast Asia and Indian subcontinent—"Far East" | Rhabdophis species (e.g., Yamakagashi) | Cobras (Naja species; e.g., Indian cobra, Philippine cobra, king cobra, [Ophiophagus hannah]) and kraits (Bungarus species; e.g., common krait and banded krait) | Daboia russelli subspecies (e.g., Russell's viper) and Echis species (saw-scaled viper) | Malayan pitviper (Calloselasma rhodostoma), Hypnale species (e.g., hump-nosed viper), Trimeresurus species (e.g., Asian lance headed vipers, bamboo snake, Habu), Agkistrodon species (e.g., Mamushi), and Deinagkistrodon acutus (Chinese copperhead) | |
| Australasia | Boiga species (e.g., brown tree snake) | Australasian Elapids (e.g., taipan, common death adder, common brown snake, and black tiger snake) | ... | ... | |
| Europe | Can be present in the region | ... | "European vipers" (Vipera species; e.g., common adder and sand viper) | ... | |
| North and Central America | Can be present in the region | Coral snakes (Micrurus species) | ... | Rattlesnakes (Crotalus species; e.g., Eastern and Western diamondback rattlesnake, Mojave rattlesnake) and moccasins (Agkistrodon species; e.g., American copperhead) | |
| Central and South America | Can be present in the region | Coral snakes (Micrurus species) | ... | Lanceheads (Bothrops species; e.g., common lancehead and Jararaca cascavel), Crotalus durissus subspecies, and bushmaster (Lachesis muta subspecies) | |
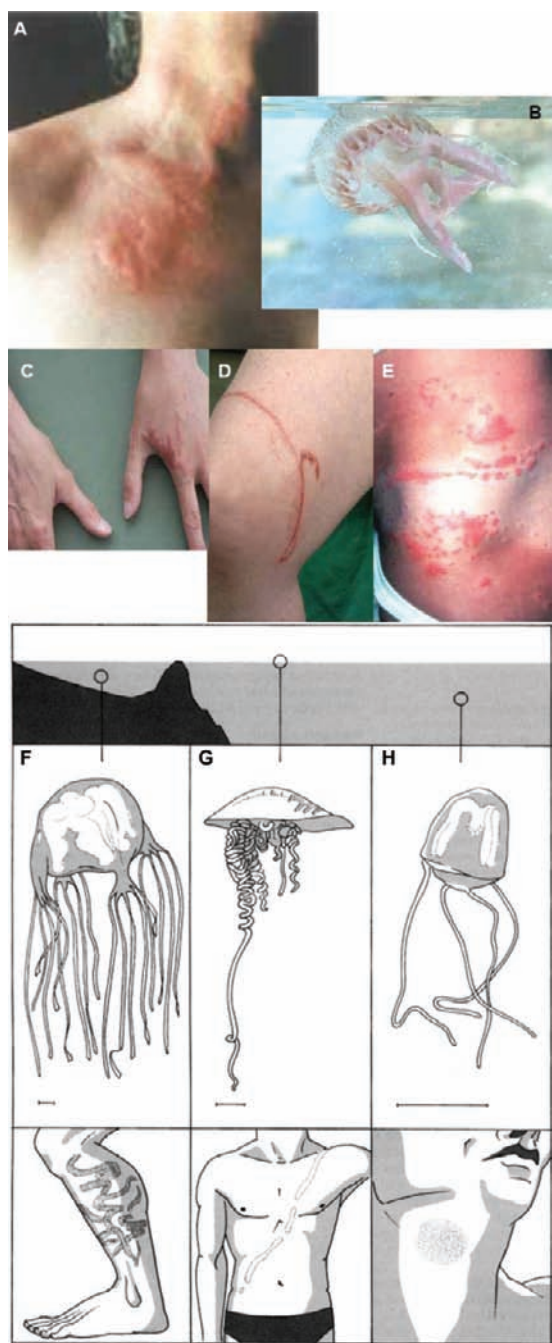
**Figure 2.** *A,* "Print" of *Pelagia noctiluca; B, Pelagia noctiluca* specimen; *C,* flare-up reaction of a *Pelagia noctiluca* print 10 days after the primary contact; *D,* print from a *Physalia physalis* tentacle; *E,* print of sea lice (*Linuche unguiculata*) at the contact area under the swimming suit. Ecological, morphological, and clinical features of dangerous jellyfish: *Chironex fleckeri* may reach a bell diameter of 20 cm, and prefers shallow coastal waters. Tentacle prints show the typical ladder pattern for this animal *(F)*. *Physalia* species—in fact, not a single individual, but a colony of symbiotic polyps—floats on the water surface with the help of a gas-filled bladder and produces whip-like tentacle prints *(G)*. *Carukia barnesi* (Irukandji), a pelagic box jellyfish, is the size of a human thumb. After heavy storms it may be found in the inward zone of a reef. The nematocysts of the bell produce a faint print on the skin *(H)*.

have been envenomed by the box jellyfish *Chironex fleckeri* [15]; however, only this antivenom's effect on pain and possibly on skin damage is of proven value. Calcium antagonists (e.g., verapamil) are no longer recommended as treatment.
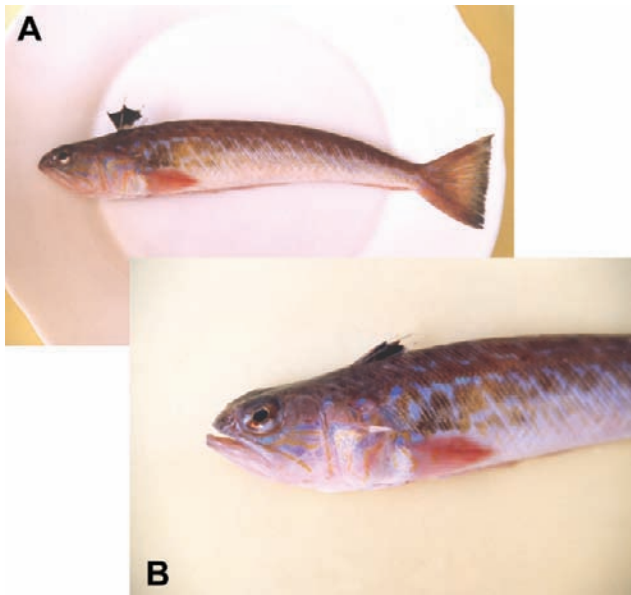
## Venomous Fish

***Biology.*** Venomous fish carry venom-gland–bearing fin rays for self defense. The venom glands are located mainly in the dorsal fins, but they can also be found in the ventral and anal fins (as observed in scorpion fish, lion fish, and stone fish, which are marine animals) or in the dorsal and pectoral fin (in catfish—mostly freshwater species). Stingrays have 1 or more serrated stings, located on their whip-like tails, that may exceed 30 cm in length. Freshwater stingrays (*Potamotrygon* species) are found in rivers and lakes in South America and Africa. Weever fish (of the Mediterranean and Eastern Atlantic coastal waters) and toad fish possess venomous stings on their gill covers and in the dorsal fins (figure 3).

In many species, the venom apparatus seems to have evolved along with a sedentary life style in shallow waters for use as protection from enemies attacking from above. While wading in shallow waters, bathers can be stung in the foot, ankle, or calf. Divers are at risk of stings from slowly swimming lion fish, which may suddenly attack if disturbed. In fish markets and when preparing venomous fish for consumption, handlers must be vigilant because stings remain dangerous: the venom continues to be active after the fish has been killed [3, 5].

***Clinical features.*** Stings from venomous fish cause agonizing pain. Mechanical injury destroys tissue, which is followed by further damage caused by the local effect of the injected venom. In rare instances, deeply penetrating stings can affect large blood vessels and major nerves. Some species of venomous fish can cause systemic envenoming [3, 4, 16, 17].

***Prevention and first aid.*** Careful observation of the bottom of shallow waters, swimming (instead of wading), and avoiding free-swimming venomous fish are the most important preventive measures. Because panicking as a result of severe pain and the systemic effects of venom increases the risk of drowning, victims must be brought ashore as quickly as possible. Immersing the stung limb in hot water (<45°C) is an effective first aid measure [3, 4].

***Clinical management.*** Pain control, wound management, and tetanus prophylaxis are essential. Whenever possible, a local nerve block with an anaesthetic is most effective. Mechanical injury, remaining fragments of spines, and tissue damage caused by injected venom may require surgery. Secondary bacterial infections (e.g., with *Vibrio* species or *Pseudomonas* species) are common and require special antibiotic recommendations. Antivenom is available only for stone fish envenoming; although its efficacy has never been formally evaluated, marked pain relief has been demonstrated in case series [3, 4, 16–18].

**Figure 3.** Weeverfish *(Trachinus* species), found in the Mediterranean Sea. Venomous spines are located on the dorsal fin *(A)* and the gill cover *(B).*

### Sea Snakes

***Biology.*** Some 50 species of sea snakes form a specialized snake family that is now classified as *Elapidae.* With the exception of 2 species, *Hydrophis semperi* and *Laticauda crockeri,* all sea snakes live in the marine environment; however, some may enter the mouths of rivers. *Pelamis platurus* is a pelagic species that drifts across the Indian and Pacific Ocean, carried over large distances by currents. All other species are found in coastal waters; the beaked sea snake *(Enhydrina schistosa)* and the annulated sea snake *(Hydrophis cyanocinctus)* are the 2 most prominent species. Sea snakes are mainly a hazard to fishermen in the subtropics and tropics, who are bitten when emptying fishing nets or when wading in shallow, muddy waters [5, 19].

***Clinical features.*** Rhabdomyolysis is the main feature of envenoming by sea snakes. Early clinical signs are muscular pain and tenderness followed by placid paralysis and renal failure. In nearly all cases there are no local warning signs of venom injection; bite marks are virtually invisible. Well-documented case series have been published on *E. schistosa* bites [19]. Single case reports of *Astrotia stokesi* bites suggest neurotoxic modes of action of the venom of this species [4].

***Prevention and first aid.*** As with venomous fish, wading in shallow, muddy waters and handling snakes—including dead ones—should be avoided. Pressure immobilization is recommended and is supported by several case reports [4, 19].

***Clinical management.*** Administration of antivenom is indicated as soon as signs and symptoms of systemic envenoming become obvious. Dialysis and respiratory support are important supportive measures [4, 19].

### Scorpions

***Biology.*** Scorpions inflict painful stings when squeezed or handled. Most medically important species belong to the family *Buthidae;* as a rule of thumb, these animals possess more slender pincers than their less dangerous relatives. Systemic envenoming is caused by members of the genera *Centruroides* (found in the Southwest region of the United States and in Mexico); *Tityus* (in Brazil and Trinidad); *Androctonus, Buthus, Leiurus,* and *Nebo* (in North Africa and the Near and Middle East); *Hemiscorpius* (in Iran, Iraq, and Baluchistan); *Parabuthus* (in South Africa); and *Mesobuthus* (on the Indian subcontinent). Scorpions are nocturnal arthropods that live in or near houses; most encounters between these animals and humans happen here. Travelers are stung when they accidentally squeeze scorpions that are hiding in beds, luggage, shoes, and clothing [20].

***Clinical features.*** Local envenoming causes pain, erythema, and swelling. Systemic envenoming usually develops in 2 stages: a cholinergic phase involving vomiting, sweating, hypersalivation, priapism, bradycardia, and arterial hypotension, followed by an adrenergic phase involving arterial hypertension, tachycardia, and cardiac failure. Cranial nerves and neuromuscular junctions may also be affected. Respiratory failure can precipitate and is multifactorial, including bronchial hypersecretion [21–25].

***Prevention and first aid.*** Checking shoes, clothing, luggage, and beds for scorpions is the most important individual preventive measure, and sealing holes and cracks in walls of houses reduces hiding places. First aid measures, such as splinting of the affected limb and crepe bandages, have never been systematically tested.

***Clinical management.*** Local pain is controlled with local anaesthetics and regional anaesthesia. Wound management and tetanus prophylaxis are important. Treatment preferences of systemically envenomed patients vary widely. Control of the effects of an overstimulated autonomic nervous system with α-blockers (e.g., prazosin), calcium-channel blockers (e.g., nifedipine) and ACE inhibitors (e.g., captopril) has been successfully achieved in Israel and India. In Saudi Arabia and the Americas, the use of antivenoms is regarded as an equally important component of treatment [21–28].

### Spiders

***Biology and clinical features.*** Spiders employ venom jaws that are connected to venom glands to catch prey and for use in self defense. Few species are medically important; most spiders either have venom jaws that are too small to penetrate human skin or their venom is too weak to produce substantial envenoming.

Spider bites may go unnoticed until clinical signs and symptoms develop, which may be confined to local erythematous edema. Brown recluse spiders cause necrotic lesions around the

bite site that are known as "necrotic araneism": local edema and ischaemia at the bite site are early features, which develop into frank necrosis (eschar) within days and occasionally develop into extended necrotic areas over weeks. South American bird spiders ("tarantulas") can, when disturbed, rub off urticating hairs from their abdomens with their hind legs. Systemic neurotoxic envenoming is caused by widow spiders (*Latrodectus* species, common between latitudes 50°N and 45°S), wandering spiders (*Phoneutria* species, found in South America), and funnel web spiders (*Atrax* species and *Hadronyche* species, found in southeast Australia) and resembles envenoming from scorpion stings. The clinical course of envenoming by these spiders is also predominantly triggered by catecholamine release. Brazilian 'banana spiders' (*Phoneutria nigriventer)* have been reported to travel in bunches of bananas, causing bites and even deaths in countries to which they are not native. Like scorpion stings, spider bites occur in and around houses—in particular, from spiders in the genera *Latrodectus* and *Loxosceles*. Outdoor activities such as camping are also common settings for spider bite incidents [2–4, [29]–34]. For prevention and first aid, the same rules as for scorpion stings apply.

***Clinical management.*** Local venom effects are either trivial, only requiring routine wound management (including tetanus prophylaxis), or can cause severe problems because of tissue necrosis around the bite site. Management of necrotic araneism remains controversial. There are strong arguments for routine wound management alone; however, published case series of *Loxosceles* bites from Australia and South Africa indicate that cases of systemic envenoming, especially those that involve agonizing muscle spasms, respond well to antivenom treatment. Funnel-web spider antivenom is equally beneficial for patients who become envenomed by members of the *Atrax* and *Hadronyche* genera [2–4, 29–34].

**Hymenopterans (with a Focus on Bees, Wasps, and Ants)**

***Biology.*** Hymenopterans are insects that inject venom with a stinging apparatus connected to venom glands in the terminal part of the abdomen. Some species of ants lack a sting and, instead, squirt their venom.

Honeybees and wasps are widely and numerously distributed in cold and tropical climates; therefore, most humans experience multiple stings during a lifetime. Single stings are dangerous for people who are allergic to the venom or if the site of the sting is located in the throat. Envenoming in the true sense (i.e., experiencing the direct toxic effects of the venom) is rare and requires hundreds or even thousands of stings in adults. Direct toxic effects, as opposed to allergic reactions, account for <5% of all deaths caused by hymenopteran stings [35].

***Prevention and first aid.*** People who know that they are allergic to hymenopteran venom should be advised to carry a first aid kit and, most importantly, should be trained to inject themselves with adrenaline (e.g., with an EpiPen). Hyposensitization therapy should be offered to patients who have severe allergic reactions. Bee stings should be removed as quickly as possible, because they continue to pump venom into the tissues even after they are separated from the body of the bee [35].

***Clinical features.*** In nonallergic people and for single stings, local toxic effects (including pain, redness, and swelling) are the only clinical feature. Multiple stings induce extensive swelling that can lead to hypovolemia and hemolysis, neurological disturbances, myolysis, and renal failure. The major threats of hymenopteran stings are, however, hypersensitivity reactions, which can be severe and life-threatening. The prevalence of honeybee and wasp venom allergies in the North American population is 3.3% in adults and 0.8% in children. Systemic signs and symptoms (e.g., flushing, tachycardia, abdominal colic, or diarrhea) develop within a few minutes after a sting. If left untreated, this can progress into hypotension, coma, and death [35].

***Clinical management.*** Adrenaline, steroids, and antihistamines are the cornerstones to counteract the allergic effects of hymenopteran venom. Most important and life-saving is 0.1% adrenaline (0.5–1.0 mL for adults, 0.01 mL/kg for children), administered intramuscularly, for patients with sting anaphylaxis. Local wound management and tetanus prophylaxis should be performed if needed [35].

**Venomous Terrestrial Snakes**

An estimated 50,000–100,000 people die each year from snake bites alone, and many more suffer from permanent disability [36]. The rural populations of the tropics and subtropics suffer most of all, because the habitats of snakes and humans overlap; recreational travelers, however, rarely experience snake bites. In a case report of a 21-year-old Swiss student in the Amazon rainforest near Manaus, Brazil (figure 4), the student suddenly felt a sharp pain in his right foot while walking with a friend on an overgrown footpath in the evening. He was wearing open sandals. After the pain occurred, he noticed something moving away from the path through the vegetation. Later, he became aware of 2 bleeding puncture wounds on his right foot. On the way back to the camp he felt increasingly dizzy. The foot became swollen and painful 1.5 h after the incident. Within an hour, the swelling extended across the lower leg, up to the thigh, and the lymph nodes in the groin became enlarged. Suspicion of a snake bite as the most probable cause grew, and the 2 men decided to set off to the nearest settlement (~2 h away on foot). After covering one-half of the distance, the pain became intolerable and the student gave up. In despair, he photographed the developments in the appearance of his right leg. His friend carried on to seek help and returned after one-half of an hour with a few men. They built a stretcher from wood and carried the student to the nearest road leading out of the forest, where

**Figure 4.** Photographs taken by a 21-year-old Swiss student documenting the course of envenomation after being bitten by a snake on his right foot *(arrow)* in the Amazon rainforest near Manaus, Brazil. Photographs were taken 6.5 *(A),* 67 *(B),* and 96.5 *(C)* h after the bite.

a pick-up truck stopped and drove him to the hospital in Manaus. Upon arrival, he had cross swelling of the entire right leg and his blood was incoagulable. He received antivenom and made a near-full recovery, with the exception of his right leg, which over months continued to hurt and swell up when walking.

*Biology.* Venomous snakes have fangs located in the front of the upper jaw that contain venom ducts that run along the inside of the fangs. Venom is produced in specialized salivary glands. In elapids (the *Elapidae* family), fangs are fixed and are of small or moderate size. In vipers (viperids, of the family *Viperinae)* and pit vipers (crotalids, of the family *Crotalinae),* the fangs are mostly large and mobile. Pit vipers derive their name from a heat-sensitive pit organ located between the eye and the nostril that is used for orientation and, in particular, for locating prey. Many species of the large colubrid family *(Colubridae)* possess toxins in their salivary glands, which are mounted at the base of the teeth in the hind part of the upper jaw (table 1) [2–4, 37, 38].

*Clinical features.* The chemical makeups of snake venom,

which vary by species, subspecies, and even geographic variant level, induce a wide range of clinical signs and symptoms. Subdivision of symptoms into local, autopharmacological, antihemostatic, neurological, muscular, cardiac, and renal effects helps to stage the patient. In conjunction with information on geographic distribution, habitat, and behavior of the snake, the clinical pattern of signs and symptoms is useful to identify the culprit. In some snake bites (those of crotalids, viperids, and some cobras), but not in others (those of kraits, coral snakes, and some Australasian elapids), local swelling indicates that venom was injected, and absence of swelling reliably excludes clinically relevant envenoming. A particular local problem is chemical conjunctivitis and, in severe cases, corneal ulceration and perforation caused by the venom emitted by spitting cobras. Autopharmacological effects of snake bites can lead to extravasation of circulating fluid and hypovolemic shock and to clinical features that resemble true type I hypersensitivity reactions—particularly in cases of evenomation by viperids and crotalids. Incoagulable blood and bleeding are common in patients who have been envenomed by viperids, crotalids, Australasian elapids, and colubrids. In the case of envenomation by viperids and crotalids, blood coagulation is additionally compromised by toxin-induced disruption of the capillary endothelium. Paralysis, which eventually also affects respiratory muscles, is caused by the venom of elapids, Australasian elapids, and very few crotalid and viperid species. Rhabdomyolysis occurs from the bites of very few viperid, crotalid, Australasian elapid species, and sea snakes. Acute renal failure is mostly caused by hypotension and shock [2–4, 37–39].

*Prevention and first aid.* Boots and long, heavy trousers are essential to avoid snake bites. Carrying a torch at night is useful, as is stepping hard on the ground when walking (because snakes are sensitive to vibration). Sleeping on the ground without a sewn-in ground sheet should be avoided; camp beds are recommended. Bed nets are also protective.

There is no universally applicable method to reliably delay the transport of venom from the bite site into systemic circulation without causing damage. Tourniquets cause severe tissue destruction, depending on the pressure exerted. Cut and suction devices (e.g., "venom-ex") designed to remove venom from the local tissues are not only entirely ineffective, but are also dangerous. The same applies to electric shocks, instillation of chemical compounds, cryotherapy, and "snake stones." Instead, calming and immobilizing the patient (i.e., by splinting bitten limbs and carrying patients) after an accident are crucial. More effective is the application of a crepe bandage to compress lymphatic vessels, thereby impeding systemic spread. Correct application of crepe bandages, however, poses many practical problems, including the application of the recommended pressure of 55 mm Hg. Experimentally, this method has been studied in Australia; its clinical efficacy, however, has never been validated. In regions

wherein snakes cause local envenoming, crepe bandages may give rise to severe adverse effects [2–4, 37–39].

*Clinical management.* Clinical management of snake bites ideally relies on both symptomatic supportive treatment and specific antivenom therapy. Because most accidents happen in remote areas that have limited resources, remedies are in short supply or may not be available at all. This is especially true for antivenoms, which, worldwide, are in very short supply, are frequently of poor quality, and are very expensive. For decades, pleas have been made to national and international bodies to speed antivenom development and to increase production and distribution of these life-saving remedies, without much, if any, success [40–42]. Indications for antivenom use are the signs and symptoms of systemic envenoming: (1) hypotension or other signs and symptoms of autopharmacological reactions, (2) hemostatic abnormalities or spontaneous systemic bleeding, (3) paralysis, (4) rhabdomyolysis, (5) cardiovascular signs and symptoms, and (6) renal impairment. In local envenoming, antivenom is indicated if (1) the species that has inflicted the bite is known to cause local necrosis; (2) there is swelling that involves more than one-half of the bitten limb; (3) there is rapidly progressive swelling; and (4) there are bites on the fingers or toes [2–4, 37–40]. One has to be well aware that signs and symptoms of envenoming can be very much delayed, thereby necessitating the observation of patients ⩾24 h after a bite. Depending on the antivenom available (monospecific, polyspecific), the culprit has to be identified to a (sub)species or even geographic variant level, a process that can be complicated by the whole range of problems mentioned above. The quality of antivenoms—namely, their severe adverse effects in approximately one-half of the patients to whom crude antivenoms are administered—makes monitoring and treatment of side effects an important part of managing envenomed patients. Pretesting for allergic reactions is unreliable [43]. Premedication with subcutaneous adrenaline has shown some effect in 1 study [44]. Repeated doses of antivenom are often required because of prolonged absorption of venom from the bite site. In travel clinics, the question is often asked whether antivenoms should be carried along when traveling in remote areas in which snake bites are a problem. As a rule, the answer is "no," because the decision to give antivenom, its application, and the management of adverse effects requires medical skills and appropriate equipment.

In addition to antivenom treatment, supportive medical care (e.g., respiratory support and renal replacement therapy) is regularly needed in the event of a snake bite. Incoagulable blood and consecutive hemorrhage must be diagnosed early to initiate and repeat antivenom therapy, if needed. For this purpose, the 20-minute whole-blood clotting test is a simple and adequate bedside test to assess blood coagulability. Treatment of local tissue damage around the bite site ranges from simple wound man- agement to debridement for extensive necrosis [2–4, 37–39]. Because bacteria can be introduced by the fangs of the snake and can cause subsequent wound infection, including abcesses, tetanus prophylaxis must be boosted. Wounds should be followed-up and antibiotics should be given when indicated; however, antibiotic prophylaxis does not seem to be of advantage [45–47]. Compartment syndrome is rare and should be diagnosed only after measuring compartment pressure [2–4, 37–39].

## CONCLUSIONS

Accidents caused by encounters with venomous animals are some of the most neglected health threats affecting predominately poor rural communities. International attention and response is needed to ameliorate this problem [41, 42]. Although travelers rarely face life-threatening accidents, morbidity—particularly caused by venomous marine animals—is of importance in this group. Given the current level of international mobility of individuals, clinicians and travel clinics need to be able to give advice on the prevention, first aid, and clinical management of envenoming.

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