Key Features of North American Venomous Snake Bites

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PRACTICE **POINTS**

- Venomous snake bites require prompt medical attention and assessment of symptoms to determine the optimal course of management and need for antivenin.
- Envenomation may cause may cause discoloration and swelling of the skin as well as thrombotic or paralytic changes.

The North American venomous snake families Viperidae and Elapidae are common causes of snake bites and associated with cutaneous findings such as edema and discoloration. Because of variations in venom composition, it is important for dermatologists to have knowledge of snake identification and treatment modalities for venomous snake bites. Most Viperidae hemorrhagic toxins cause local tissue reactions and may be managed conservatively, while Elapidae neurotoxins can induce paralysis and typically require treatment with antivenin. Reversal of symptoms and recovery are highly successful if bites are identified and treated in a timely manner.

North American venomous snakes traditionally are classified as members of either the Viperidae (eg, rattlesnakes, copperheads, cottonmouths) or Elapidae (eg, coral snakes) families and account for roughly 5000 to 10,000 reported envenomations annually.[1,2] In 2021, America's Poison Centers reported 2287 calls related to copperheads, 71 related to coral snakes, 229 related to cottonmouths, 1184 related to rattlesnakes, and 524 related to unknown snakes.[3] The majority of calls related to snake bites were for adult patients, resulting in absent to minor outcomes. Only 1 death due to a rattlesnake bite was reported.[3] Death by envenomation from a North American snake species is considered rare and typically is attributed to a lapse in medical attention; however, rattlesnakes are the most common reported cause of death by snake envenomation (Figure 1).[1,3] A study comparing snake bites and hospital stays in the southeast vs southwest United States found that the southeast had the highest incidence of copperhead bites (37%), while

FIGURE 1. Rattlesnake (*Crotalus atrox*). Credit: CDC/Edward J. Wozniak, DVM, PhD.

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The authors have no relevant financial disclosures to report.

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Cutis. 2025 March;115(3):E9-E13. doi:10.12788/cutis.1186

the southwest had a higher incidence of rattlesnake bites (70%); those who were bitten by a rattlesnake were reported to have more severe symptoms and greater need for medical attention and antivenin.[4] Some reports have linked pediatric and elderly patients to worse outcomes.[5] However, one study examining 24,388 emergency department visits for snake bites from 2006 through 2014 found that the majority of pediatric cases were handled by non–trauma centers in the southern United States,[6] supporting evidence found by Campbell et al[7] indicating that most snake bites in children can be managed with conservative care. Though reported complications—including weakness, paralysis, hypovolemic shock, thrombocytopenia, and death—from North American venomous snake bites are low, they are still considered a medical emergency.[8] It is essential for physicians to understand the clinical manifestations and treatment of North American venomous snake bites and to educate patients on how to protect themselves against and avoid provoking snakes, particularly in rural areas.[2] In this article, we review the characteristics of common North American venomous snakes and the clinical manifestations of their bites. We also discuss the appropriate measures for staging, evaluating, and treating snake envenomation to improve patient management and care.

FIGURE 2. Cottonmouth snake (*Agkistrodon piscivorus*). Credit: US Fish and Wildlife Service/Grayson Smith.

FIGURE 3. Copperhead snake (*Agkistrodon contortrix*). Credit: CDC/James Gathany.

Features of North American Venomous Snakes

Individual snakes within the Viperidae family vary in size, markings and coloration, activity, and region, and physicians should consult their local health departments regarding snakes that are common in their area.[2] Cottonmouth snakes are semiaquatic and traditionally are found within the southern and central United States. With a spade-shaped head and distinct two-tone coloration, cottonmouths may be mistaken for other nonvenomous water snakes in these regions (Figure 2).[2] Copperheads, true to their name, are red in color; they inhabit a large portion of the southeastern United States and eastern Texas regions and are the cause of the majority of venomous snake bites in North America (Figure 3). Both cottonmouths and copperheads are believed to bite and envenomate as a defensive mechanism when provoked.

Coral snakes, found in the eastern United States and Texas regions, are the only subspecies of the Elapidae family (Figure 4).[2,9] They can be distinguished from the nonvenomous milk snake by their characteristic banding, as coral snakes are patterned in a red-yellow-black band sequence and milk snakes are patterned in a red-black-yellow or white sequence. The differences in appearance of these snakes often is remembered by the phrase "red on yellow kills a fellow."

Anatomic differences between the Viperidae and Elapidae families, including fang size, placement, and type, as well as venom composition, are directly linked to clinical manifestations of the bites. Viperidae fangs extend from the maxillary bones and are mobile, long, and hollow, making it easy for the snake to control fang movement and envenomation.[9] Viperidae snakes are uniquely capable of inflicting puncture wounds without the injection of venom, known as dry bites. In contrast, Elapidae snakes have short, hollow, and fixed fangs, and thus

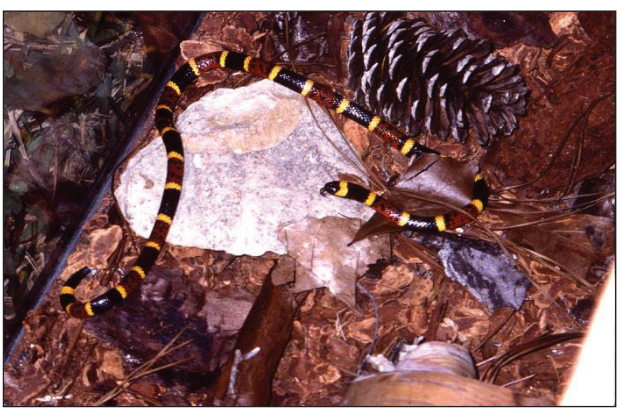

FIGURE 4. Coral snake (*Micrurus fulvius*). Credit: CDC/Edward J. Wozniak, DVM, PhD.

patients can protect themselves by wearing appropriate clothing and covered footwear.[9] Currently, identifying the type of snake responsible for the bite relies on visualization of the snake and/or the identification of clinical symptoms of envenomation by a dermatologist.

Clinical Manifestations of Venomous Snake Bites

Clinical manifestations and cutaneous findings often are used to grade the severity of venomous snake bites as well as to dictate treatment procedures. Grade 0 indicates a bite has occurred without envenomation, while grades I to V describe the progression and severity of envenomation.[10] Grade I describes minimal erythema and edema around the site (fang marks may or may not be present) and no systemic symptoms.Grade II describes erythema and edema extending up the extremity to the first joint (eg, hand to wrist), pain, some systemic symptoms if there is rapid progression, and potential bleeding at the site. Grade III describes erythema and edema spreading to the second joint in the extremity, pain, and systemic symptoms, including coagulation defects. Grade IV describes erythema and edema of the whole extremity, a rapid reaction and progression following the bite, and risk for compartment syndrome. Grade V includes erythema and edema beyond the extremity and increasing systemic symptoms.[10]

Local pain and edema, usually on easily accessible or exposed extremities, are the most common clinical symptoms reported following a Viperidae snake bite.[11] Due to their capability of producing a dry bite, puncture markings alone do not indicate envenomation. Patients will need to be monitored for several hours for signs of envenomation, which may include swelling, pain, ecchymosis, and indications of systemic manifestation (eg, weakness, dizziness, nausea, severe hypotension, thrombocytopenia).[11] Viperidae venom hemorrhagic metalloproteinases act on capillary blood vessels by cleaving basement membrane proteins and allowing for extravasation of fluid into local tissue.[12] The inflammatory response produced at the site of envenomation likely is due to the release of tumor necrosis factor α and endogenous matrix metalloprotein.[12] There is a higher risk for death associated with bites from rattlesnakes within the Viperidae family because their venom contains a unique neurotoxin that works by blocking presynaptic junctions and causing a range of paralytic symptoms from ptosis to respiratory failure.[13]

The severity of Elapidae bites is thought to be related to the amount of venom injected, the size of the victim, and the length of the snake. Though clothing may offer protection, envenomation occurs in 75% of coral snake bites and can produce devastating consequences due to the venom content.[14] In a retrospective study between 2002 and 2004, 90% of Elapidae snake bite patients (n=82) reported local pain, redness, and paresthesia, while around 7% developed systemic symptoms.[15] Elapidae venom primarily is neurotoxic and is thought to spread via lymphatics.[16] Delayed reactions are common and may take up to 12 hours to develop. Patients should be monitored, as local reactions may progress to weakness, fasciculations, extremity paralysis, and lastly, respiratory paralysis. Due to the risk for progression, all patients with likely coral snake bites should be given antivenin.[8,15,17]

Much like the North American coral snake, the venomous snake species *Gloydius blomhoffii*—referred to as the salmosa or mamushi snake depending on the region of origin (ie, Korea or Japan)—is a frequent source of devastating rural snake bites due to neurotoxins (Figure 5). The species' slender fangs are thought to directly inject the snake's potent venom, which contains hemorrhagic toxins and α-neurotoxins and β-neurotoxins, into the bloodstream; however, the salmosa is considered a viper like the North American cottonmouth and copperhead because of its triangular head shape and hollow fangs, which allow for the accommodation of venom-containing glands and mechanism of venom injection. Salmosa venom shares both Viperidae and Elapidae characteristics. Cutaneous findings such as progressive edema, erythema, and bleeding frequently are reported and are attributed to the proteases and hemorrhagic toxins characteristic of vipers (Figure 6). α-Neurotoxins and β-neurotoxins, similar to the proteolytic venom of the Elapidae family, are responsible for the unique visual disturbances (binocular diplopia) caused by the salmosa.[12,18,19]

Treatment

Treating snake bites begins with assessing the patient's airway, breathing, and circulation, followed by a thorough medical and encounter history (including description of how the bite occurred). Due to the range of Viperidae symptoms, it generally is recommended that patients remove any restrictive clothing or jewelry near the bite and/or over the affected limb or body part, place the affected body part at the level of the heart, and go to the nearest medical facility for prompt care. Historically, empiric antibiotics often were used to prevent wound infections; however, studies have since demonstrated that

FIGURE 5. Korean Salmosa snake (*Gloydius blomhoffii*). Credit: Rich Vinson, MD, Mountain View Dermatology, El Paso, Texas.

FIGURE 6. Digital extremity with necrosis, erythema, and edema following a snake bite by the Salmosa snake (*Gloydius blomhoffi*). Credit: Rich Vinson, MD, Mountain View Dermatology, El Paso, Texas.

antibiotics are not necessary and lack efficacy in uncomplicated snake bites.[16,20] In a study of 114 pediatric cases from 1995 to 2005, it was determined that most patients could be managed with conservative treatment directed at pain management and swelling reduction via elevation of the affected extremity.[6] While conservative management may be all that is needed to care for the majority of cases, one retrospective study from Texas indicated that 70% of pediatric venomous snake bites were treated with either intravenous antibiotics and/or antivenin, highlighting the variability in management and opportunity for improvement.[21]

Antivenin, specifically antivenin (Crotalidae) polyvalent, is the indicated treatment for Viperidae hemorrhagic or coagulopathic envenomation.[13,22] Per guidelines from the World Health Organization, physical examination will yield a grading of the snake bite based on cutaneous findings. Grades III to V are considered moderate to severe and should be given antivenin.[23] Physicians should look for signs of progressive injury and coagulopathy, such as increased swelling, bruising, hypotension, or altered mental status.[22] Due to the major neurotoxic risks associated with Elapidae venom, all coral snake bites should be treated with antivenin; early intubation and ventilation may be considered. [13] Similarly, patients who report a salmosa snake bite require prompt treatment with antivenin and/or cepharanthine, an additive agent to reduce swelling and pain.[18] Due to the nature of the neurotoxins contained in the salmosa venom (α-neurotoxin causing postsynaptic inhibition of the neuromuscular junction and β-neurotoxin inhibiting neurotransmitter release from the presynaptic terminal), anticholinesterases, which work by blocking the enzymatic breakdown of the neurotransmitter acetylcholine, should not be used.[19] While bleeding and skin and systemic changes may be reversed by antivenin, visual changes are unlikely to resolve with antivenin administration due to the presynaptic binding of β-neurotoxin and the blockade of neuromuscular signaling.[19]

Antivenin should be administered intravenously for the fastest onset of action in a setting suitable for the management of anaphylaxis.[24] In situations when the benefits may outweigh the risks (eg, if the patient has had a prior allergic reaction or is not in an environment where they can be watched for at least 8 hours for progression of envenomation or adverse reactions), premedication with an antihistamine or epinephrine may be considered.[17] Per the World Allergy Organization and World Health Organization, adverse reactions should be treated with crystalloid solutions and antihistamines, corticosteroids, or epinephrine as indicated.[25] In a qualitative analysis of emergency physicians' attitudes toward antivenin, most expressed treatment hesitancy due to lack of knowledge and experience using the medication.[26] When possible, snake bites should thus be managed in consultation with a toxicologist.[2]

Conclusion

Snake bites and envenomation occur commonly in the United States due to exposure to a variety of venomous snakes in the North American Viperidae and Elapidae families. Appropriate and successful management of snake bites by physicians requires general knowledge of regional snakes, the cutaneous and systemic manifestations of snake bites and envenomation, and current treatment methods.

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