DOI: 10.24906/isc/2018/v32/i6/179818

Feature Article

Snake, Snakebite and its Management – The Indian Scenario

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Abstract

Snakes are ubiquitous in India. There are many varieties of snakes with hundreds of species spanning across the country. It follows that snakebite is also a major problem in India. Snakebite deaths in India contribute to almost half of all global snakebite deaths annually. Those who survive are often left maimed and disfigured, accompanied by lifelong disabilities. Snakebites are managed at the field-level by providing psychological boost to the patient and by administering first aid. At the hospital-level, envenomed patients are treated by antivenom therapy, which is the only definitive treatment for venomous snakebites. These aspects have been discussed in detail in this review.

Introduction

Snakes have fascinated man since time immemorial. They have ignited the imagination of people across the globe, from diverse backgrounds, races, ethnicities, and religions. Their mention can be found in various texts since the earliest times of recorded history. They have been a reason for awe and fear in the minds of mankind, which has led to snake worship in various cultures, as early as the Egyptian civilization, over 5,000 years ago. Even to this day, snakes are worshiped in various parts of India. Snakes have inspired many legends and have been the topic of many mythological tales.

Since lay people do not know much about snakes, they are misunderstood and feared. In India, the majority of the snakes are harmless, except for four species that account for thousands of deaths annually. Snakes can be as small as just a few centimetres, but can grow up to 10 metres in length. Snakes can live in a wide variety of habitats, which range from scorching hot deserts, humid tropical forests, freezing Himalayan climes, and even the deepest oceans. Moreover, snakes have a variety of fascinating skin colourations, which are possibly rivalled only by the ornate and colourful wings of butterflies. However, the graceful movements and sheer elegance of snakes remain unparalleled in nature.

Historical records indicate that as far back as 326 BC, when Alexander the Great invaded India, he was very impressed by the adeptness of the Indian physicians in treating snakebite patients[1]. Since then, India has been known for its notoriety for venomous snakes and the mortality and morbidity caused by their bites.

Venomous Snakes of India[2]

There are over 270 species of snakes in India, of which 60 are venomous. Some of these are abundant and can cause very severe envenoming.

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Classification of Venomous Snakes

On the basis of fang type and venom type, venomous snakes are classified as *Solenoglypha* (retractable fangs and hemotoxic venom) and *Proteroglypha* (fixed fangs and neurotoxic venom). Venomous snakes are classified into the following five families:

- ***Viperidae:*** This family includes the *"true vipers"*. They have thick bodies and heads that are much wider than their necks. They come in many different sizes, markings and colours. They have long, hollow, moveable fangs that perform like hypodermic syringes. Their venom is highly hemotoxic that attacks the blood cells. The most common example is Russell's viper.
- ***Elapidae:*** This family includes the cobras and kraits. These elapids have highly neurotoxic venom that attacks the nervous system, causing respiratory paralysis and their fangs are fixed and immovable.
- ***Crotalidae:*** This family includes the so-called *"pit vipers"* because they have a heat sensitive pit located between the eye and nostril on either side of the head. Examples of crotalids include the bamboo pit viper, Himalayan pit viper and hump-nosed pit viper.
- ***Colubridae:*** This family has the largest number of snakes in the world. These are known as the *"back-fanged"* snakes because their fangs are pointed backwards and are mostly harmless to man. The most common example is the boomslang, which is present in sub-Saharan Africa.
- ***Hydrophidae:*** As the name suggests, this family includes all the sea snakes, which have a variety of colours and shapes. These snakes have highly neurotoxic venom that is more toxic than cobra venom. Examples include the black & yellow sea snake, hook-nosed sea snake, and yellow-lipped sea krait.

Medically Important Venomous Snakes

There are four medically important snakes in India, which account for the highest mortality. These include the Indian cobra or spectacled/ biocellate cobra (*Naja naja*), Russell's viper (*Daboia russelii*), common krait (*Bungarus caeruleus*), and saw-scaled viper (*Echis carinatus*). These are briefly highlighted below:

- **Indian Cobra:** These are also called spectacled or biocellate cobra (*Naja naja*), since they have a distinctive *"spectacle-like"* marking on their hood. This is one of India's most common snakes and is distributed across India, except the north-eastern states, Jammu & Kashmir, Uttarakhand, and Himachal Pradesh. It is approximately 2.2 m in length, fast and alert, and is active both by day and night. It is also a very good swimmer. It eats rodents, toads, frogs, and birds. Another common type of cobra is the monocled or monocellate cobra (*Naja kaouthia*).

Figure 1: Spectacled Cobra

Figure 2: Monocled Cobra

- **Russell's Viper:** This viper, scientifically known as *Daboia russelii*, is named after Dr. Patrick Russell, who discovered it in 1796 along the Coromandel Coast. It is distributed pan India, expect in Jammu & Kashmir. Its venom is highly hemotoxic. It is approximately 1.8 m in length. The snake is usually nocturnal in habit, usually slow but strikes very fast and hunts by ambush. When disturbed, it hisses loudly and bites only as a last resort. It feeds on rodents.
- **Common Krait:** Scientifically known as *Bungarus caeruleus*, this snake has the most potent venom of all Indian land snakes. It is distributed across India, except in Arunachal Pradesh, Uttarakhand, Himachal Pradesh, and Jammu & Kashmir. The venom is highly

neurotoxic and is 15-times more toxic than cobra venom. It kills by respiratory paralysis. It is approximately 1.7 m long and is nocturnal in habit. It feeds on rodents, lizards, and frogs.

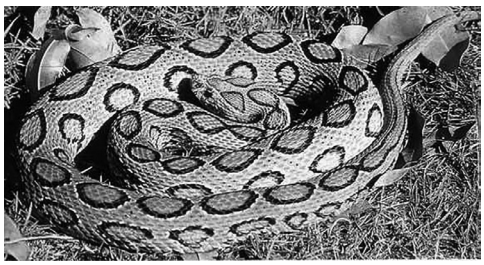

Figure 3: Russell's Viper

Figure 4: Common Krait

Figure 5: Saw-scaled Viper

- **Saw-scaled Viper:** This is also known as carpet viper (*Echis carinatus*). It is distributed across India, except in Jammu & Kashmir, West Bengal and the north-east.

  It is extremely dangerous because it comes in frequent contact with humans, causing the highest number of snakebite deaths in India. Its venom is highly hemotoxic. Its average length is 80 cm, mainly nocturnal in habit and moves by fast side-winding motion. It eats mice, lizards, frogs, scorpions, and insects.

King Cobra – A Snake that Merits Special Mention!

The King Cobra (*Ophiophagus hannah*) is the longest venomous snake in the world and can grow up to a staggering 19 feet! It is distributed in northern India, bordering Nepal as well as in eastern India, including West Bengal, Odisha, Bihar, Chhattisgarh, and Jharkhand. It is also present in all the states of the north-east. Besides these states, King Cobras are particularly plentiful in the dense jungles along the Western Ghats.

King Cobra is extremely fast, highly alert, and very aggressive. It is possibly the only snake that has some degree of intelligence. It is capable of injecting up to 7 ml of highly neurotoxic venom in a single bite, which kills by attacking the nervous system. This amount of venom is so toxic that it is capable of killing up to 20 adult humans or even an adult elephant! Death occurs within 10 minutes. Moreover, since there is no antivenom for King Cobra, death is inevitable. However, it rarely comes in contact with humans, since it lives primarily in dense jungles. Hence, fatalities from King Cobra are rare. One peculiar feature of this snake that should be noted is that it eats other snakes. That's why it's called *"Ophiophagus"*, which in Greek, means *"snake-eating"*.

Figure 6: King Cobra

Venomous Sea Snakes

There are two important venomous sea snakes along the Indian coastline and in the Indian Ocean.

- **Hook-nosed Sea Snake:** This is scientifically known as *Enhydrina schistosa* and is the most common Indian sea snake. It is found along the entire coastline of India, as well as in the waters surrounding the Andaman & Nicobar Islands. It can grow up to 5.2 feet in length. Its venom is 4-10 times more toxic than cobra venom. Fishermen are particularly at risk of being bitten by this snake. This snake primarily feeds on fish.
- **Yellow-lipped Sea Krait:** This is also called banded sea snake and is scientifically known as *Laticauda colubrina*. It is found throughout the Indian Ocean. It can grow up to 4.9 feet in length. It is nocturnal in habit and its victims are usually fishermen. It feeds on eels and other fish.

Other Venomous Snakes

There are other venomous species that are present in specific geographical areas, which can also cause a substantial number of snakebite fatalities. These include the monocled/monocellate cobra (*Naja kaouthia*) in the north-east, greater black krait (*Bungarus niger*) in the far north-east, central Asian cobra (*Naja oxiana*) in the far north-west, Wall's krait (*Bungarus walli*) and banded krait (*Bungarus fasciatus*) in the east, and Sindh krait (*Bungarus sindanus*) in the west, and the hump-nosed pit-viper (*Hypnale hypnale*) in the Western Ghats.

Non-venomous Snakes[3]

There are approximately 31 categories of non-venomous snakes in India, which includes hundreds of species. Of these, six major species are briefly highlighted below:

- **Indian Rat Snake:** As the name suggests, these snakes are rat-eaters, although they are also known to eat mice, frogs, toads, birds and lizards. Rat snakes, scientifically known as *Ptyas mucosa*, are the most common and familiar snakes in India. They are large (up to 11.5 feet in length; males larger than females), fast terrestrial snakes that are active by day and are good climbers. They are excitable and likely to bite if picked-up, but become docile when handled gently.
- **Common Vine Snake:** As the name suggests, these snakes are bright green in colour and look like vines. Scientifically known as *Ahaetulla nasuta*, these are medium-sized to large (up to 6.6 feet in length; females larger than males) and slow, slender, diurnal snakes with pointed snouts. Vine snakes have eyes with horizontally elliptical pupils and binocular vision. They will bite if handled. They eat lizards, frogs, mice and small birds.
- **Checkered Keelback:** Scientifically known as *Xenochrophis picastor*, these snakes are so called because they have a checkered pattern and a distinct keel (fold) on their back. They are common, small to medium-sized, nocturnal/diurnal snakes and mostly found in or around ponds. They eat fish, frogs, rodents, and birds.
- **Indian Rock Python:** Scientifically known as *Python molurus molurus*, they are very large (up to 25 feet in length; females larger than males), slow, and mainly nocturnal snakes, which climb and swim well. They are constrictors (kill by constriction by wrapping around the prey) and feed mostly on mammals and birds, sometimes reptiles and amphibians.
- **Ornate Flying Snake:** Scientifically known as *Chrysopelea ornata*, they are medium-sized (up to 5.7 feet in length), slender, active, diurnal tree snakes that do not actually fly, but glide through the air. They are excellent climbers. Like pythons, they are also constrictors that feed on geckos, rodents, bats, and birds.
- **Red Sand Boa:** Scientifically known as *Eryx johnii*, they are sometimes nicknamed *"two-headed snake"* because their head and tail look alike. They are slow, stocky, medium-sized (3.3 feet in length; females larger than males) burrowers which are nocturnal and live on sandy soil. They are distant relatives of the boa constrictors of South America. That's why they're powerful constrictors and feed on amphibians, reptiles, rodents, and birds.

Snake Venom[4,5]

Snake venom is the poisonous fluid stored in the venom glands, which are actually modified salivary glands, located at the back of the head.

- **Secretion of Venom:** The venom is secreted through the venom canal and fangs into the snake's prey. Fangs are of two types, namely fixed and retractable. The fixed fangs do not move and are typically present in elapids such as cobras and kraits. The retractable fangs are capable of moving back-and-forth and are present in the vipers such as the Russell's viper and saw-scaled viper.
- **Composition of Snake Venom:** Snake venom is composed of a complex cocktail of toxins, and it is this complexity that is responsible for the widely differing effects of snakebites. The snake venom toxins are primarily of two types: the hemotoxins that attack the blood and the neurotoxins that attack the nervous system. The former are present in the vipers, while the latter are present in the elapids. Other toxins include cardiotoxins that are toxic to the heart, and cytotoxins, which are toxic to cells. The toxins are predominantly (~90%) made-up of proteins and peptides. Some of these exhibit specific effects on various biological functions, such as blood clotting, conduction of nerve impulses, and blood pressure regulation, amongst others. Snake venom is rich in enzymes, especially hydrolytic enzymes. Enzymes in snake venom make-up approximately 80-90% of viper venom and 25-70% of elapid venom. These include phospholipase, phosphodiesterase, L-amino acid oxidase, protease, peptidase, metalloprotease, and nuclease, to name a few. These enzymes in snake venom help to immobilize and digest the prey and also provide defence against threats.
- **Medical Uses of Snake Venom:** Venom is used for producing antivenom that is used for treating snake envenomation. Some medicines have also been derived from snake venom. For example, hemotoxins have been used to produce drugs for treating high blood pressure, heart attack, and blood disorders. Neurotoxins have been used to develop drugs for treating brain disorders and stroke. The first venom-based drug to be developed is Captopril, derived from the Brazilian pit viper and used for treating high blood pressure. Other drugs developed from snake venom include Etifibatide from rattlesnake and Tirofiban from African saw-scaled viper, which are used for treating heart attack and chest pain.

The Snakebite Problem in India[6]

Snakebite is a very serious medical problem in India. It is estimated that the total number of annual snakebite deaths globally is approximately 100,000, whereas the total number of snakebite deaths in India is 49,900 annually. Therefore, India alone contributes approximately 50% of the global snakebite deaths! These figures clearly show the magnitude of the snakebite problem in India. Moreover, these statistics could be a gross underestimate as these data are based primarily on hospital records and most snakebite deaths go unreported, especially in remote rural areas. The situation is further aggravated by traditional snakebite healers called *"Ojhas"* who are incompetent in treating venomous snakebite, thereby appreciably increasing the death toll.

In India, snakebite deaths predominantly occur in rural areas (97%), are more common in males (59%) than females (41%), and peaks during the monsoon months of June to September. The age group of 15 to 29 years experience the highest burden of snakebite deaths. The states with the highest burden of snakebite deaths include Uttar Pradesh (8,700), followed by Andhra Pradesh (5,200) and Bihar (4,500).

Signs & Symptoms of Venomous Snakebite[7]

The signs and symptoms of envenoming depend on the type of venom injected, which are primarily hemotoxic or neurotoxic in nature. Some of the major symptoms of envenomation by vipers and elapids are tabulated below:

Vipers (Russell's Viper & Saw-scaled Viper); Venom Type: Hemotoxic

Local Symptoms	Systemic Symptoms
Pain at bite site (not always)	Bleeding gums
Ecchymosis (bruising)	Hemorrhage in the gut
Swelling	Epistaxis (bleeding nose)
Blister formation (Russell's viper)	Hematemesis (blood in vomit)
Necrosis (Russell's viper)	Hemoptysis (blood in sputum)
Bleeding from bite site (Saw-scaled viper)	Hematuria (blood in urine)
Rapid discoloration at bite site (Saw-scaled viper)	• Melena (blood in feces) • Renal failure (Russell's viper) • Coagulopathy (clotting abnormalities) • Hypotension (low blood pressure)

Elapids (Cobra & Common Krait); Venom Type: Neurotoxic

Small puncture marks (not always visible)	Sluggish pupillary response Ptosis (drooping eyelids)
Minimal or absent local symptoms	• Diplopia (double vision)
	• Dilated pupils
	• Difficulty swallowing
	• Difficulty breathing
	• Difficulty speaking
	• Arrhythmia (irregular heartbeats)
	• Hypotension
	• Respiratory arrest
	• Cardiac arrest
	• Loss of consciousness
	• Coma

Management of Snakebite[8]

Management of snakebite involves both psychological and medical approaches.

Psychological Management: This is very important, as many snakebite deaths can occur due to fear or anxiety. The patient must be reassured. Panicking must be avoided at all costs, as this can compromise judgement, thereby increasing the chances of making mistakes while attending to the patient. It should be noted that excessive panicking on the part of the patient can prove to be fatal, even from non-venomous snakebites.

Medical Management: This involves administering treatment in the form of field-based *"First Aid"* and hospital-based definitive treatment by *"Antivenom Therapy"*.

First Aid

First Aid should be short, simple and quick. Not much time should be wasted on it. First Aid involves reassuring the patient, immobilizing the bitten limb, and arranging for transportation.

The currently recommended First Aid is based on the mnemonic ***"Do it R.I.G.H.T."***, which involves the following:

R = *Reassure* the patient, due to the following reasons:

- Approximately 65-70% of total snakebite cases are due to non-venomous snakes.
- Only 50% of venomous snakebites actually cause envenomation.
- Approximately 85-90% of venomous bites do not develop any signs and symptoms of envenoming.

I = *Immobilize* the limb as for a fracture.

- Use cloth to hold the splints in place.
- Don't apply too much pressure, as this can block the blood supply.
- Don't apply any compression in the form of tight ligatures, as these are ineffective and can be dangerous.

G.H. = *Get* to the *hospital* immediately.

- Don't waste time in visiting traditional healers such as *"Ojhas"*.

- Traditional remedies have no proven benefit against venomous snakebites.

T = *Tell* the doctor about any systemic symptoms that may have been observed.

The Do's and Don't's

It is very important that certain things should be done, while others should not be done. These so called do's and don't's are briefly highlighted below:

Do's

- Reassure the patient that death is rare as most bites are non-venomous and that medical care is available.
- Remain calm and control anxiety. Make the patient feel relaxed. Excitement can elevate blood pressure and increase blood circulation, which will spread the venom much faster throughout the body.
- Lay the patient flat on the back and keep the bitten limb below the level of the heart.
- Remove shoes, watches, tight clothing, rings, bracelets and amulets as these can cause obstruction in case of swelling.
- Be ready to carry out cardiopulmonary resuscitation (CPR) on the patient.

Don't's

- Don't apply a tourniquet as the blood supply to the bitten limb will be cut-off. This can cause necrosis and even gangrene, which may require amputation.
- Don't apply any chemical solution such as potassium permanganate on the bite site.
- Don't cut the bitten area to extract the venom as viper bites can cause uncontrollable bleeding due to non-clotting blood, as a result of which the patient may bleed to death.
- Don't use electric shock therapy as it doesn't work.
- Don't freeze or apply extreme cold on the bite site.
- Don't apply any herbal or folk remedies, including snake stones on the bitten area as there is no scientific proof of their efficacy.
- Don't attempt to suck-out venom with your mouth, since the venom could spread into your body in case you have an ulcer. It can also spread infection into the bite site from bacteria present in your mouth.
- Don't use any suction devices to remove the venom as these don't work and could cause harm to the patient.
- Don't give the patient any alcoholic drinks or drugs. Only water can be given in moderation and paracetamol can be given for relieving pain.
- Don't try to capture, handle or kill the incriminating snake to bring to hospital for identification. Instead, take a photo with your mobile camera if the snake is still in the vicinity.
- Don't waste time going to traditional healers, *Ojhas*, or quacks as they are incapable of treating venomous snakebites. They only appear to succeed as most bites are non-venomous. Only antivenom therapy is life-saving in case of venomous snakebites.

Antivenom Therapy

Antivenom therapy is the only scientifically proven treatment for venomous snakebites. This is discussed below:

Discovery of Antivenom: Snake antivenom was discovered by Dr. Albert Calmette, a French physician, bacteriologist, and immunologist who was attached to the Pasteur Institute in Paris. Calmette, who was a close associate of Louis Pasteur, developed snake antivenom in 1894, while at the Pasteur Institute.

He demonstrated that it is possible to *"hyperimmunize"* an animal with increasing doses of venom. A second envenomated animal can be saved by the serum of the immunized animal. This antivenom was popularly known as *Calmette's serum*. Calmette immunized horses to produce the antivenom. This discovery is still the basis for the production of modern antivenoms.

Antivenom Production: The first step in the production of snake antivenom is extraction of the venom from snakes. The head of the snake is held firmly and the fangs are anchored to the corner

of a petri dish and the venom glands are gently squeezed to *"milk"* the snake. The venom collects within the petri dish. The venom is dried and then solutions are made at graded concentrations in double distilled water or saline. Next, horses are immunized with increasing doses of the venom over a span of 1-2 months. This stimulates the immune system to produce antibodies against the venom. After completion of the immunization course, the horses are bled from the jugular vein in the neck. The blood is allowed to clot and the serum is separated. The antibodies in the serum are purified, which are the active components of the antivenom. The antivenom is available in both liquid and lyophilized (freeze-dried) forms. The liquid form is less stable and requires a cold-chain for storage and has a 2-year shelf-life.

The lyophilized antivenom is available as a powder and is more stable. It requires only to be kept cool while in storage and has a 5-year shelf-life.

Antivenom may be monovalent (raised against a single species of snake) or polyvalent. Indian antivenom is polyvalent, meaning that venoms from several species of snakes are immunized to raise the antivenom. In India, the venom from the *"Big Four"*, namely Russell's viper, Indian cobra, common krait, and saw-scaled viper are used for producing the antivenom. Therefore, Indian antivenom is effective against all of the above four medically important snakes.

Antivenom Treatment: Antvenom is very expensive and in short-supply. Therefore, it should be administered only when envenomation is confirmed. The antivenom dose may vary with the degree of envenomation i.e. mild or severe envenomation. Each vial contains 10 ml of antivenom. Generally 8-10 vials of antivenom are required for treating an envenomated patient. However, higher doses (20 vials or more) may be required in very severe cases. It is to be noted that children should receive the same dose of antivenom as adults.

Since, antivenom is raised in horses; the antibodies are foreign to the human body. This can lead to adverse serum reactions. Anaphylaxis is a life-threatening condition that can occur due to antivenom reactions. In this situation, the antivenom must be stopped immediately and epinephrine (adrenaline) should be administered to control the anaphylaxis.

Antivenom Manufacturers in India

In India, polyvalent snake antivenom is available against the *"Big Four"*. Currently, there are seven snake antivenom manufacturers in India, which are listed below:

- Haffkine Bio-Pharmaceutical Corporation Ltd., Mumbai
- Bharat Serums and Vaccines Ltd., Mumbai
- Serum Institute of India Ltd., Pune
- Bengal Chemicals and Pharmaceuticals Ltd., Kolkata
- Central Research Institute (Govt. of India), Kasauli
- Biological E. Ltd., Hyderabad
- VINS Bioproducts Ltd., Hyderabad

Prevention of Snakebites

Prevention is always better than cure as per the old proverb, which says *"An ounce of prevention is worth a pound of cure"*. Therefore, it is recommended to take some preventive measures to avoid snakebites, which include the following:

- Avoid places where snakes may live. Snakes can hide inside heaps of leaves, firewood, as well as piles of coal or cow dung cakes used for cooking purposes in rural areas.
- While walking at night, always wear heavy boots and long trousers. Use a torch to see the path in front of you. Tread heavily, as this will create vibrations on the ground, which can be detected by snakes and they will move away.
- Use a stick to poke the ground in front of you while walking on rough terrain. This will scare away any snakes.
- Avoid sleeping on the floor, especially in rural areas, as there is a chance of being bitten by kraits, which enter homes in search of food at night.
- Avoid bathing in ponds, streams and rivers after

dusk as this can increase chances of being bitten by venomous snakes such as cobras, which can be mistaken for non-venomous checkered keelbacks due to the low visibility. It should be noted that cobras, like checkered keelbacks, are good swimmers.

- Never handle a snake, even if it's dead. It can bite by reflex action!

Conclusion

Snakebite burden in India remains the highest in the world, yet it is still grossly underestimated. Since the largest proportion of global snakebites is contributed by India, global snakebite estimates, could also be underestimated. There is an urgent need for proper community education, awareness programs, appropriate training of medical personnel, and better availability and distribution of antivenom, especially in the 13 states with the highest prevalence of snakebites. This could significantly reduce snakebite deaths in India.

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