INTRODUCTION
Snake bite envenomation is a common acute life-threatening medical emergency. More than 200,000 snake bites are reported in the country and an estimated 35,000 to 50,000 people die each year. Majority of snake bite deaths go unreported as many victims go to traditional healers and many deaths occur before reaching hospital.

Aetiology
There are about 216 species of snakes identifiable in India, of which 52 are poisonous. The major families of poisonous snakes in India are Elapidae which includes common cobra (*Naja naja*, Figure 1A), king cobra and common krait (*Bungarus caeruleus*, Figure 1B), Viperidae includes Russell’s viper (Figure 1C), *Echis carinatus* (saw scaled or carpet viper, Figure 1D) and pit viper and hydrophidae (sea snakes). Snake venom is not a substance evolved to attack man or big vertebrates, but is intended to paralyse the prey before swallowing. Venom secretion in all venomous snakes appears to vary in seasons. In warmer months its output is more than in the cold season. Similarly, darker the snake, more is the venom it secretes. Most snakes inject 10% of available venom in a single strike except Russell’s viper which injects 75% of stored venom in one bite and is responsible for high morbidity and mortality in India.

Pathophysiology
Snake venoms are not single toxins but a cocktail of many components: enzymes, polynucleotide toxins, non-toxin proteins, carbohydrates, metals, lipids, free amino-acids, nucleotides and biogenic amines. The content and potency of venom in any snake varies with size, age, diet, climate, and time of year. Moreover, a small snake’s immature venom may not respond to routine anti-snake venom.

Pro-coagulant enzymes are the major factor in viper venom, which stimulates blood clotting and consumption of fibrinogen, causing disseminated intra-vascular coagulation (DIC). Russell’s viper venom contains several different pro-coagulants which activate various steps of the clotting cascade. Fibrinolytic activity of the viper venom is so fast that sometimes within 30 minutes of the bite, the coagulation factors are so depleted that blood does not clot. Haemorrhagins are zinc metalloproteinases, which damage the endothelial lining of the blood vessels causing spurting of red blood cells and spontaneous systemic bleeding. Cytolytic or necrotic toxins damage the cell membranes and stimulate apoptosis. These digestive hydrolases, polypeptide toxins and other factors increase permeability resulting in local swelling and non-healing ulcers and gangrene of the bitten part. Haemolytic and myolytic phospholipases A2 (PLA2) damage cell membranes, endothelium, skeletal muscle, nerve and red blood cells. Pre-synaptic neurotoxins are phospholipids A2 that damage nerve endings, initially releasing acetylcholine transmitter, then interfere with its release. Post-synaptic neurotoxins are polypeptides which compete with acetylcholine.
for receptors in the neuromuscular junction and lead to curare-like paralysis (cobra venom).

The amount of venom injected at the time of bite depends on the species and size of the snake and the mechanical efficiency of the bites. At times snake may be able to control whether or not venom is to be injected at the time of bite. This is the reason why irrespective of bite by poisonous snake, there is no systemic sign of envenomation, i.e. dry bite.

**Echis carinatus or Saw scaled Viper or Carpet Viper**

It is 1 to 3 feet long, head is sub-ovate with short rounded snout, body is cylindrical, short and covered with rough, serrated flank scales, neck is distinctly constricted. It is pale brown or tawny with dark brown. A cruciform or trident or arrow type or just like the bird foot print shaped mark is seen on head. It flourishes in hot and humid climate in the coastal regions of India. It is alert, diurnal in habit and capable of quick movement when necessary. It hibernates in the winter. Readiness with which it bites on smallest provocation with extremely rapid strike makes it one of the more dangerous snakes. It forms a double coil in the form of figure of 8 with its head in the centre a striking position. It is viviparous producing 3 to 15 young at a time. It injects 0.0046 gram venom at the time of bite. Farmers, hunters, labourers, and persons walking barefoot in jungles and rocky areas are often bitten by this snake.

**Clinical Manifestations**

Local – Within an hour of the bite, swelling develops over the bitten part. Fang marks or abrasions with clotted blood are seen (Figure 2). Venom is of big molecular size and is circulated through the lymphatics, hence within 60 to 120 minutes the victim experiences a painful lymphadenopathy of the drainage area of the bitten part. Ecchymoses are seen over the bitten part or may spread over lymphatic drainage areas. Acute bleeding in the form of gum bleeds (Figure 3) or bleeding from abrasions on any other part of body or from vene-puncture sites is seen within 90 to 120 minutes of a bite. Occasionally, in untreated patients, bleeding can persist for 1 to 2 weeks in the form of blood-stained sputum, haematuria and then disappears of its own. Such patients are markedly anaemic and report to hospital for weakness or non-healing bleeding cellulitis. Natural immunity against the *Echis carinatus* venom develops in cases of repeated bites by the same species in endemic areas as reported in Jammu region. Renal failure due to *Echis carinatus* has been reported from Puducherry and Jammu areas, but not from Maharashtra.

**Russell’s Viper or Daboia or Viper russellii siamensis**

It inhabits ten south Asian countries and ranks amongst the topmost important causes of snake bite mortality. While protecting the paddy and wheat from the rodent (rats) population, it kills many farmers unlucky enough to tread on it. It is a 3 to 5 feet long snake; the head is covered with small scales and without shields. The body is massive and cylindrical, narrowing at both ends; the head is flat, triangular with short snout, large gold flecked eyes with vertical pupils and large open nostrils. Its belly is round with constricted neck. Typical rows of oval arranged in two rows is characteristic of Russell’s viper. Its natural prey includes mice, rats, frogs, lizards, snakes, and birds. The young snakes are cannibalistic. The females produce 20 to 60 young usually around the month of June or July. Length of fangs in an adult snake is 16 mm and curved. The amount of venom injected at the time of bite is 63 ± 7 mg.

**Clinical Manifestations**

Local – The victim experiences severe local pain at the site of the bite, active bleeding from fangs marks within a few minutes, rapid swelling progressing to the whole limb within six to eight hours (Figure 4). Ecchymoses and blebs occur over the bitten part. Because of oedema of muscle and bleeding there is development of compartment syndrome characterised by swelling, painful passive movement, and loss of sensation over the nerve areas passing through the compartment. Subsequently, wet gangrene or non-healing ulcers develop. Lymph nodes proximal to the bite become enlarged and tender.
**Systemic Manifestations**

Hypotension and shock are due to sudden liberation of bradykinin into the circulation, bleeding and loss of fluid in swollen part, bleeding in the adrenal glands, or peritoneal or massive blood loss by haematemeses or haemoptysis.

**Haemostatic failure:** Procoagulant content of venom initiates rapid thrombosis, hypofibrinogenaemia and consumptive coagulopathy. In human victims of Russell's viper bite, the injected dose of venom is insufficient to cause massive fatal intra-vascular coagulation within a minute of the bite, unlike in animals. Once the patient's blood has become defibrinated and incoagulable, spontaneous systemic bleeding ensues. Haematuria, bleeding in the skin, and pituitary haemorrhage can occur. Russell's snake bite victims can subsequently develop amenorrhoea, Sheehan's syndrome, loss of libido due to hypopituitarism, as reported from southern India. Enhanced capillary permeability is seen in the form of pleural and pericardial effusion, ascites, and conjunctival congestion/haemorrhage. High fatality is due to hypotension and resistant shock syndrome due to capillary leaks.

**Renal failure:** 20% to 40% cases subsequently develop anuria, oliguria and acute renal failure. Renal angle tenderness is the most important clinical sign for early diagnosis of renal failure. There is serial rise in blood urea and serum creatinine with acidosis and hyperkalaemia. Tubular damage by venom itself, interstitial nephritis, haemoglobinuria, hypotension, and microthrombi in the kidney contribute to acute tubular necrosis. Renal failure is the commonest cause of death.

**Neurological effects:** Ptosis, bulbar palsy, inter-nuclear ophthalmoplegia and respiratory paralysis due to presynaptic neuromuscular block in a Russell's viper bite has been reported from Kerala and Sri Lanka.

Green pit viper and bamboo pit snakebite cases, reported from Kerala, are characterised by local oedema and rarely a systemic bleeding disorder. Coagulopathy and renal failure has been reported due to Hump-nosed pit viper snake bite.

**Elapidae Poisoning**

Common Indian Krait (Bungarus caeruleus); local names – kala gandait, kala taro, kandar, manyar, chitti, kattu viriyan, valla pambo.

Krait is the most poisonous snake, its venom being ten times more poisonous than cobra venom. It is 1 to 4 feet long, with enlarged hexagonal vertebral scales, uniform white or red belly and narrow white crossbars on the back, more or less distinctly in pairs, the crossbars are typically absent near the head and neck region. The common krait resides in the vicinity of human habitation, near the wattle and daub, mud and small hut dwellings. Krait is a nocturnal, terrestrial snake that enters human dwellings in search of prey such as rats, mice, and lizards. It eats even the small snakes (cannibalism). The common krait is regarded as the most dangerous species of venomous snake in the Indian subcontinent. Most bites occur during the cooler months of June to December when snakes may, during the course of their hunting activity, linger in a person's bedding to take advantage of the warmth therein.

**Clinical Manifestations**

Majority of the cases of snake bite are reported between 11 pm to 5 am, usually when the person is asleep and the reflexes are greatly diminished; and the krait, having sharp small fangs, injects maximum venom in such a person. The victim might experience mild pain at the site of bite, paraesthesia or numbness, without any local marks or swelling or bleed, hence the bite is neglected and falsely initially attributed to an ant or rat. Venom is small molecular size hence directly absorbed in the circulation. The venom stimulates the autonomic nervous system thus within 20 to 30 minutes of the bite, victims experience a transient abdominal colicky pain, bradycardia, sweating, vomiting, raised blood pressure. Subsequently, within 30 minutes to 18 hours the venom attacks the postsynaptic acetylcholine receptors resulting in ptosis (Figure 5 a, b, c), pulling of saliva, dysphagia, dyspnoea, inter-nuclear ophthalmoplegia, weakness of neck muscles, respiratory muscles and lastly the diaphragm. Patient complains of blurred vision,

![Figure 4: Extensive swelling due to Russell's viper bite and recovery after 8 days.](image)

![Figure 5: Manifestations of krait bite: (a) ptosis with bulbar palsy, (b) after recovery, (c) fang marks over the ear lobules.](image)
diplopia and lands in respiratory paralysis, coma and anoxic cardiac arrest. Venom induced paralysis of pupillary muscle causes non-reacting pupils. After recovery, a few patients had signs and symptoms of peripheral neuropathy. Many a times, patients succumb to iatrogenic respiratory infection or adult respiratory distress syndrome.

**Cobra Bite**

Cobra bite tends to occur during the day time, when the transportation is more readily available. Moreover, because of its known severity, victims report to hospital early.

Cobra venom is a potent cardiotoxic, neurotoxic, haematotoxic and cytotoxic. The fangs of a cobra are small and sharp. Its venom is small molecular size hence rapidly absorbed into the circulation.

Soon after a bite, the victim experiences severe pain at the site of bite with fang marks covered with blood clots. Rapid development of swelling over the bitten part, ecchymoses, blebs, and massive damage of skin and subcutaneous tissue due to myocytolysis can occur. If the victim saw the biting hooded cobra, massive liberation of endogenous catecholamine into the circulation due to fear of death can actually result in lethal cardiac arrhythmias or cardiogenic shock due to massive myocardial infarction. Sinus bradycardia, A-V block and hypotension are due to cardio-depressant action of the venom.

Sudden respiratory arrest without any other neurological manifestations can occur resulting in anoxic cardiac arrest. Rapid ptosis and bulbar palsy accompanied with respiratory depression can occur. Rarely, haematotoxic effects are seen. Blurring of vision and loss of accommodation are the earliest neurological signs of envenomation.

**Locked-in syndrome:** Thus may be seen in few cases, but such victims recover totally within 3 to 4 days if treated properly by maintaining oxygen saturation with proper ventilator support, maintaining electrolytes and nutrition and prevent iatrogenic infection. This phenomenon is due to blocked post-synaptic acetylcholine receptors including papillary muscle which are rich in acetylcholine receptors.

**Sea Snakes**

Sea snakes are seen all over the coastal region. Sea snake is accidentally handled by fishermen during fishing. Its venom is neurotoxic, myotoxic and haematotoxic. Soon after a bite, the victim experiences severe muscle pain, marked tenderness all over the muscles, trismus, muscular paralysis, respiratory arrest, without local manifestations at the site of bite. Myotoxic effects of venom causes hyperkalaemia and myoglobinuria causing acute tubular necrosis.

**Management**

Figure 6 outlines the management of snakebite envenomation. Reassurance is important to allay anxiety and fear of death. Local incision, tight tourniquet or suction, and electric shock are to be discouraged. Patient should be shifted to the nearest equipped medical facility. Immobilisation of the bitten part by a splint, keeping the bitten part below heart level is preferred. It is worthy to apply crepe bandage (with a pressure enough that one can easily introduce the finger between skin and bandage) to krait bite case if victim took > 30 minute but less than 2 to 3 hours to reach the hospital. This helps to delay the absorption of venom and moreover may prevent rapid development of respiratory paralysis.

**Treatment with Anti-snake Venom (ASV)**

History of snake bite or evidence of fang marks are not an indication for administration of ASV. There should be signs and symptoms suggestive of envenomation.

Initially 100 mL ASV is to be added to 200 mL of crystalloid solution administered over 60 minutes by intravenous route in

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<td>Saw scaled viper</td>
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**Figure 6:** Flow chart for management of snake bite.
a victim of krait, cobra and Russell’s viper envenomation. It neutralises the circulating venom. While the venom is absorbed slowly from the site of the bite, which acts as a depot, can be neutralised by 20 to 30 mL of ASV at 6-hourly intervals.

In case of elapidae envenomation, 50 mL of ASV can be administered if there is no improvement within 30 to 60 minutes after the initial dose; while the total initial dose required for *Echis carinatus* envenomation is 20-40 mL over one hour and 20 mL over the next 24 hours.

ASV may be administered even after 12 to 14 days after viper bite if systemic toxicity is present. After the initial dose of ASV, if active bleeding such as haematemesis, haematuria, bleeds from the wound do not disappear within 20 to 30 minutes, particularly in viper bite, one can repeat 20-50 mL ASV as an extra bolus.

Twenty minute whole blood clotting test (20WBCT) is the gold standard bedside test and can be performed by unskilled staff. Before injecting ASV, from same venepuncture 2-3 mL of blood is withdrawn and added to a dry glass tube (not washed with detergent), and then kept standing for 20 minutes. If the tip of the blood did not clot, hypofibrinogenema is confirmed. This test should not be repeated earlier than 6 hours after administration of ASV, as the liver takes six hours for synthesis of coagulant factors. 20WBCT test decides further requirement of ASV. This test is important for diagnosis and also indicates the improvement.

Once the venom gets attached to the target organs (receptors) such as neuromuscular receptors, red blood cells, platelets, renal tubules, and myocardium, then any amount of ASV will not able to reverse the effects.

Elapidae venom blocks the acetylcholine receptors, this action of venom can be reversed by neostigmine in the dose of 25 microgram per kg per hour preceded by atropine. Post-synaptic receptors blocked by cobra venom can be totally reversed by choline-esterase inhibitor, while in krait bite venom which blocks both pre- and post-synaptic receptors, neostigmine may help to delay the respiratory depression in early stage. Need for artificial ventilation is indicated by grade 3 power, pulling of saliva, or tidal volume below 200 ml.

Hypotension, bradycardia are to be treated with dopamine drip and atropine. Complete heart block in cobra bite needs isoprenaline drip, ASV and temporary pacemaker.

**Renal failure:** Early administration of ASV, mannitol, diuretic and acetyl cysteine may help to prevent the renal failure in Russell’s viper bite. Close monitoring of urine output is important to detect early renal failure in Russell’s viper bite. Early renal failure is treated by intravenous frusemide 200-500 mg or torsemide by continuous intravenous drip and dopamine drip with fluid restriction. Haemodialysis or peritoneal dialysis may also need to be offered in established renal failure cases.

**Profuse bleeding** can be treated by blood transfusion. Shock due to accumulation of fluid in compartmental syndrome or muscles damage can be prevented by surgical decompression, but the following criteria should be fulfilled before any surgical procedure: (1) marked tenderness over muscles, (2) pain during passive movement of muscles, (3) loss of sensation or hypo-aesthesia in the supply of a nerve passing through the compartment.

**Hyperkalaemia** is managed on standard lines – intravenous calcium gluconate, diuretics, insulin-glucose drip, salbutamol nebulisation and if required, dialysis.

**Anaphylaxis** can result from ASV, but test dose of ASV is not essential. Recently, it is reported that adrenaline can be used as prophylaxis before starting ASV. Earliest symptom of anaphylaxis is vomiting sensation, warm sensation in ears or head, itching behind ears, urticaria, itching all over body, hypotension, tachycardia, bronchospasm, dysphagia, swelling of tongue and lip, feeling of obstruction in throat. ASV should not be given by rapid intravenous bolus as it may activate complements and result in a severe reaction. One should keep watch for appearance of anaphylaxis for 10 to 180 minutes after administration of ASV. While diluting ASV if there is a precipitate, it should be discarded as such precipitated proteins are more likely to cause severe anaphylaxis.

Intra-muscular injection should be avoided if the patient’s blood fails to clot.

Total requirement of ASV dose can be reduced by preparing mono-specific ASV or purified F(ab)2 ASV.

ELISA kit for detection of venom antigen helps a treating doctor know the exact species of snake and even help to monitor the circulating venom antigen, thus the dose of ASV.

**Prevention**

Firewood, dry cow dung, cattle shed and rubble should be kept away from residential areas. Old storage rubble, particularly in old house, should be handled in full sunlight. Rubble in the attic should not be handled blindly. Barefoot walking in darkness for open toilet in grown grass should be avoided, or one should go out with a torch and a heavy stick so as to vibrate the place before stepping. Proper care of rats, mice and lizards must be taken. No attempt should be made to catch the snake or to kill it. Killed snake should not be handled. Thick electric rubber gloves with rubber shoes should be worn at the time of handling the crops husk. A bamboo cot with scrupulous use of a mosquito net prevents scorpion sting, krait and mosquito bite alike. The victim should report as early as possible to the nearby primary health centre where enough storage of ASV is kept ready.

Training in appropriate use of antivenom and protocol of indications for its use should be arranged at general hospital level to ease the crisis of supply of ASV.

**RECOMMENDED READINGS**