Sasidharan *et al. International Journal of Emergency Medicine* (2025) 18:50
https://doi.org/10.1186/s12245-024-00796-x

International Journal of Emergency Medicine

RESEARCH Open Access

Clinical and demographic profiling of snakebite envenomation in a tertiary care centre in northern India

Parvathy Sasidharan[1], Nidhi Kaeley[1*], Prakash Mahala[1], Jewel Rani Jose[1], Takshak Shankar[1], Silpa Santhalingan[2], Ankit Sharma[1], Balwant Kumar[1], Mallapu Ajay Kumar[1] and Minakshi Dhar[1]

Abstract

Background Snake bites are a major cause of emergency visits in tropical countries like India, with actual mortality and morbidity likely higher due to underreporting. The aim of the study was to analyze the clinical and demographic profiles of snake bites at the Department of Emergency Medicine, AIIMS Rishikesh, over two years (July 2021 to July 2023).

Methods Patients aged over 18 with witnessed or suspected snake bites were included. Data on demographics, clinical history, laboratory parameters, treatment, and outcomes were collected.

Results Most patients were male (68.3%) and aged 31–50 years (35.6%). Farmers made up 57.4% of the cohort. Bites occurred mostly in the evening (46.5%) and during the monsoon (71.3%). Symptoms varied: 48.5% were asymptomatic, 31.7% had hemotoxic symptoms, and 15.8% experienced neurotoxic symptoms, including ptosis. Hemotoxic bites frequently involved bleeding at the bite site (93.8%) and gum bleeding (46.9%). Local complications were noted in 7.9% of cases. Neuroparalytic bites required ventilatory support in 62.5%. Blood products were administered to 31% of patients with hemotoxic bites, hemodialysis to 19%, and plasmapheresis and hyperbaric oxygen therapy to 6.3%. Out of the 69 symptomatic patients (68.3%) who received anti-snake venom (ASV), 28 (40.6%) patients developed adverse reactions.

Conclusion This study provides a detailed analysis of suspected snakebites in Uttarakhand and surrounding areas, highlighting the importance of early recognition, prompt treatment, and timely referral to prevent fatalities. The administration of anti-snake venom (ASV) is identified as the most critical intervention, though lack of awareness in rural areas complicates management. The study calls for targeted public health campaigns to educate communities about early snakebite recognition and the role of ASV. It also stresses the need for region-specific protocols and improved healthcare access, emphasizing the importance of referral systems for advanced interventions like hemodialysis and intubation. Overall, the study advocates for enhanced public awareness and healthcare infrastructure to reduce snakebite incidence and mortality in rural populations.

Keywords Snake bite, Hemotoxic, Neurotoxic, ASV, Plasmapheresis, HBOT

*Correspondence:
Nidhi Kaeley
nidhi.em@aiimsrishikesh.edu.in
[1]All India Institute of Medical Sciences, Rishikesh, India
[2]All India Institute of Medical Sciences, New Delhi, India

Background

Reptile bites, particularly snakebites, are a major cause of emergency visits in tropical countries like India, with the WHO estimating 81,000 to 138,000 deaths and 400,000 amputations annually in the Indian subcontinent [1]. However, underreporting due to limited healthcare access and reliance on alternative treatments means the true burden is likely higher. The "big four" snakes responsible for envenomation in India—Russell's viper, saw-scaled viper, common krait, and cobra—are targeted by anti-snake venom (ASV), though increasing cases of humped-nosed pit viper bites lack specific ASV. Snakebites can lead to hematotoxicity, neurotoxicity, and myotoxicity, with delayed treatment resulting in life-threatening complications like hypotension, paralysis, bleeding, acute kidney injury, and severe tissue destruction. Underreporting hampers public health efforts, making it crucial to raise awareness and improve access to timely treatment.

Methodology

This retrospective-prospective observational study, conducted in the Department of Emergency Medicine at AIIMS, Rishikesh, aimed to analyze the clinical and demographic profiles of snakebite cases over two years. Variables studied included age, sex, occupation, bite location, time of occurrence, seasonal variations, complications, snake species, clinical manifestations, treatment modalities, and outcomes. The two-year timeframe was chosen following the establishment of a toxicology fellowship at the institution in 2022, which included a dedicated ICU for toxicology patients, enhancing specialized care for snakebite victims. The retrospective portion used electronic records (e-hospital@NIC) from July 2021 to July 2022, including patients aged 18 years and older with a snakebite history. Their clinical and demographic details will be obtained from the electronic medical records of the hospital (e-hospital$^{@NIC}$). The details regarding site of bite, timing of bite, time of presentation to the ED, details of the pre hospital treatment, clinical features were noted. The treatment given as well as outcome of all the patients were documented. The details of the relevant blood investigations were obtained from the records. The prospective portion, covering July 2022 to July 2023, included patients with witnessed snakebites or clinical signs of hemotoxic or neurological envenomation. Exclusion criteria included patients without consent, those who absconded or discharged against medical advice, and those with incomplete medical records.

Convenience sampling was used, screening all patients with a possible history of snakebite for neurological symptoms (e.g., diplopia, dysphagia, dysarthria, ptosis) or hemotoxic manifestations (e.g., bleeding, hematuria, hemoptysis, hematemesis, purpura). For unwitnessed bites, diagnosis relied on history and clinical features, after excluding other differentials such as neuromuscular diseases, myasthenia gravis, botulism, Lambert-Eaton syndrome, hemolytic anemia, or acute febrile illness. Demographic data, clinical history, biochemical and hematological parameters, treatment, and outcomes (e.g., mortality, blood product use, hemodialysis, vasopressor need, complications, mechanical ventilation) were recorded.

Results

Of the 101 patients, 69 (68.3%) were male, with most (36, 35.6%) aged 31–50 years. The majority were farmers (58, 57.4%). Bites typically occurred between 4 p.m. and 7 p.m. (47, 46.5%) and were most common during the monsoon season (June–September) (72, 71.3%). Most patients (47, 46.5%) were from Uttarakhand, with others from Uttar Pradesh (36, 35.6%), Himachal Pradesh (12, 11.8%), and Haryana (6, 5.9%). Eighty-seven patients (86.1%) had lower limb bites, and 12 (11.8%) had upper limb bites. Most patients arrived at the hospital 12–24 h after the bite (87, 86.1%) (Table 1).

Pre-hospital treatments varied: 40 patients (39.6%) received no treatment, 11 (10.8%) received 10 vials of anti-snake venom (ASV), 9 (8.9%) received 2–5 vials, and 27 (26.7%) underwent traditional practices such as cutting the bite site or applying irritants. At our center, 56 patients (55.4%) received ASV, with up to 20 vials for neurotoxic bites and about 30 vials for hemotoxic bites.

Among those with a history of snakebite, 49 (48.5%) were asymptomatic, 32 (31.7%) hemotoxic, and 16 (15.8%) neurotoxic. Neurotoxic symptoms included ptosis, ophthalmoplegia (14, 87.5%), respiratory paralysis (10, 62.5%), dysphagia (10, 62.5%), limb paralysis (6, 37.5%), and unconsciousness with a GCS < 8 (2, 12.5%). Hemotoxic symptoms included subconjunctival hemorrhage, ecchymosis, and intracranial bleed (1 case each, 3.1%), gum bleeding (15, 46.9%), hematuria (12, 37.5%), hematemesis (9, 28.1%), and local bleeding (30, 93.8%). Renal dysfunction occurred in 17 (53.1%) hemotoxic cases, with 7 (21.8%) having acute kidney injury and 10 (31.2%) experiencing oliguria with metabolic acidosis. Six (18.8%) needed hemodialysis, and two (6.3%) underwent plasmapheresis. Local complications included cellulitis (5, 4.9%), necrotizing fasciitis (2, 1.98%), and compartment syndrome (1, 0.99%) (Table 2A, 2B). Of the 8 patients with local complications, 5 (62.5%) required surgical intervention, including fasciotomy or debridement, while 3 (37.5%) needed skin grafting.

All patients with hemotoxic snakebites exhibited elevated bleeding time (BT) and clotting time (CT) and a mean activated partial thromboplastin time (APTT) of 33.65 s and a PT/INR of 25.19/2.45 s (Table 3).

Table 1 Socio demographic profile of patients with snake bite

Age	< 19 years		13	12.9%
	19–30		24	23.8%
	31–50		36	35.6%
	> 50		28	27.7%
Gender	Male		69	68.3%
	Female		32	31.7%
Occupation	Farmer		58	57.4%
	Student		8	7.9%
	Home maker		10	9.9%
	Snake charmer		3	2.97%
	Others		22	21.8%
Time of bite	Morning (6 am to 12 pm)		18	17.8%
	Afternoon (12pm to 4pm)		8	7.9%
	Evening (4pm to 7pm)		47	46.5%
	Night (7pm to 6 am)		25	24.8%
	Not known		4	3.96%
Season	Monsoon (June to September)		72	71.3%
	Winter (October to February)		20	19.8%
	Summer (march to may)		9	8.9%
Geographical area	Uttarakhand		47	46.5%
	Uttar Pradesh		36	35.6%
	Haryana		6	5.94%
	Himachal Pradesh		12	11.9%
Site of bite	Upper extremity		12	11.9%
	Lower extremity		87	86.1%
	Trunk		1	0.99%
	Others		1	0.99%
Time of presentation	< 12 h		7	6.9%
	12 to 24 h		87	86.1%
	> 24 h		7	6.9%
Local treatments	False beliefs	Local application of substances like chilli/ turmeric/local herbs	12	11.9%
		Attempts at sucking the venom	5	4.9%
		Washing the site of bite	7	6.9%
		Placing incision over the site of bite	3	2.97%
	Torniquet		14	13.9%
	ASV		11	10.9%
	Incomplete ASV (2 to 5 vials)		9	8.9%
	No treatment		40	39.6%

Among 16 neurotoxic patients, 10 (62.5%) needed mechanical ventilation, with 2 (12.5%) developing ventilator-associated pneumonia and 3 (18.8%) undergoing tracheostomy. The remaining were successfully extubated. (Table 4). Hemotoxic snake bite patients (32, 31.7%) required blood products (10, 31.2%), 6 (18.8%) required hemodialysis and 2 (6.3%) required plasmapheresis. Hypotension with vasopressor support occurred in 6 patients (19%), while 3 (9.4%) had local reactions, and 2 (6.3%) required mechanical ventilation. 2(6.3%) patients were given hyperbaric oxygen therapy for the management of the local wound necrosis. (Table 5). The mortality was similar in both the groups. (Table 6).

In our study, 69 symptomatic patients (68.3%) received anti-snake venom (ASV), with 28 (40.6%) developing adverse reactions. The most common reactions included fever, chills, and rigor (64.2%), followed by nausea and vomiting (46.4%) and itching (42.9%). Severe reactions included respiratory distress (17.9%) and anaphylactic shock (10.7%).

Discussion

India accounts for nearly half of the world's snakebite-related deaths, a critical issue often overlooked in global health discussions. In 2017, the WHO recognized snakebite envenomation as a neglected tropical disease and launched a strategy to reduce deaths and disabilities by 2023 [2, 3]. Timely access to antivenom (ASV) is crucial to preventing fatalities [4]. Uttarakhand, with its hilly terrain and forests, is home to over 30 snake species,

Table 2 Clinical profile of patients with snake bite

A			
Asymptomatic		49	48.5%
Neurotoxic		16	15.8%
Hemotoxic		32	31.7%
Local reaction		8	7.9%
B			
Neurotoxic	Ptosis	16	100%
16(15.8%)	Dysphagia	10	63%
	Ophthalmoplegia	14	88%
	Limb paralysis	6	38%
	Unconsciousness	2	13%
	Respiratory paralysis	10	62.5%
Hemotoxic	Ecchymosis	1	3%
32 (31.7%)	Gum bleeding	15	47%
	Local bleeding	30	94%
	Subconjunctival haemorrhage	1	3%
	Haematuria	12	38%
	Hematemesis	9	28%
	Intracranial bleed	1	3%
	Acute renal failure	17	53%
	Shock	10	31%
Local reactions	Cellulitis	5	63%
8(7.9%)	Necrotizing fasciitis	2	25%
	Compartment syndrome	1	13%

Table 3 Lab profile of patients with hemotoxic snake bite

Parameter	Mean value	Standard deviation
aPTT (21–30)	33.65	5.08
PT (12.3 s)	25.19	3.42
INR (0.97)	2.45	0.67
Total bilirubin (0.3–1.2 mg/dl)	1.55	0.81
Haemoglobin (13–17 g/dl)	10.41	2.02
Platelet (1.5-4.5lakh/uL)	1.76	0.80
Urea (17–43 mg/dl)	99.25	89.48
Creatinine (0.72–1.18 mg/dl)	2.52	1.2

Table 4 Duration of mechanical ventilation in patients with neuroparalytic snake bites

Duration	No of cases	Percentage
Less than 24 h	3	18.8%
24–48 h	2	12.5%
>48 h	5	31.3%

Table 6 Outcomes of patients with snake bite

Outcome	Neurotoxic (16)	Hemo-toxic (32)
Need for mechanical ventilation	10 (62.5%)	2 (6.25%)
Need for hemodialysis/ plasmapheresis	-	7(21.9%)
Need for blood product administration	-	10(31.3%)
Need for surgical interventions	2(12.5%)	3(9.4%)
ICU admission	10 (62.5%)	14 (43.8%)
Death	1 (6.3%)	2(6.3%)

Table 5 Treatment modalities used in patients with hemotoxic snake bites neurotoxic snake bites

Modality	Hemotoxic bites (32)	Neuro-toxic bites (16)
Anti Snake Venom	32 (100%)	16 (100%)
Blood product transfusion	10(31%)	0
Vasopressor support	6 (19%)	0
Dialysis	6 (19%)	0
plasmapheresis	2 (6%)	0
HBOT	2(6%)	0
Surgical intervention	3 (9%)	2 (13%)
Mechanical ventilation	1 (3%)	10 (62.5%)

including venomous ones like the cobra, krait, viper, and king cobra [5]. Our hospital also treats patients from neighboring regions of western Uttar Pradesh and southern Himachal Pradesh.

Our study found that snakebites were more common among males (68.3%), consistent with Bhalla et al. (66%) and Bhat et al. (70%) [6, 7]. Unlike Russell et al. (1979) [8] and Bhalla et al. (2014) [6], who identified the 14–30 age group as most affected, we observed the highest incidence in the 31–50 age group, likely due to regional differences. Most patients (57.43%) were farmers, followed by homemakers (9.9%), students (7.92%), and snake charmers (2.97%), in line with findings by Bhat et al. [7], Saini et al. [9], and Sarangi et al. [10]. The male predominance and higher vulnerability among farmers are consistent with studies by Satyanarayan et al. [11] and Patil et al. [12]. Additionally, 21.78% of bites occurred during outdoor activities like walking through forests or trekking.

Lower extremity bites accounted for 86.1% of cases, similar to Anurekha et al. [13], as accidental stepping on snakes is common in tropical countries. This contrasts with non-tropical regions, where snake handling injuries are more frequent [14]. In rural India, where barefoot walking in the dark is common, over 90% of bites result from accidental encounters. Most bites occurred in the evening (46.5%), followed by night (24.8%), morning (17.8%), and afternoon (7.9%), aligning with studies by Bhat et al. [7], Virmani et al. [15], and Vora et al. [16], indicating that evening bites are linked to agricultural activities and reduced visibility in tall grass.

India's tropical climate causes seasonal variations in snakebites. In our study, 71.3% of bites occurred during the monsoon (June–September), 19.8% in winter (October–February), and 8.9% in summer (March–May). The monsoon peak aligns with Banarjee et al. [17] and Vora et al. [16], while Bhat et al. (2014) reported 51.3% in summer [7]. Neuroparalytic bites peaked at the end of summer and beginning of monsoon, with hemotoxic bites more common in winter [6]. The monsoon peak is likely due to increased agricultural activity and heightened snake movement from heat and rainfall [18, 19].

Patients presented within three time categories: under 12 h, 12–24 h, and over 24 h. The majority (86.1%) arrived within 12–24 h. Delays in treatment were due to remote locations, inadequate transportation, patient negligence, lack of awareness, and referral delays. Despite 67 primary health centers (PHCs) and 50 community health centers (CHCs) in Uttarakhand, 39.6% of patients received no prior treatment, often relying on local remedies that worsen conditions, leading to complications like cellulitis, compartment syndrome, and gangrene.

Tourniquet use was seen in 14 (13.9%) of patients. Tight torniquets can cause reperfusion injury and acute kidney injury [20]. But in our study, we didn't come across any cases of reperfusion injury, possibly because they were removed cautiously. Standard protocols were followed for controlled removal, with a pulse distal to the tourniquet checked before removal. For venomous bites, a loading dose of ASV was given to reduce venom surge risk. Nonvenomous bites had tourniquets removed after an IV line was established. Multiple ligatures were released in the emergency room, except for the most proximal, which was removed upon hospital admission. Blood pressure cuffs used for venom release were inflated 20–30 mmHg above the patient's systolic blood pressure (SBP) to occlude venous return while maintaining arterial flow, then deflated slowly over 10–15 min with continuous monitoring. Immediate interventions were initiated if distress signs, such as hypotension or respiratory difficulty, occurred, ensuring patient safety.

While some primary hospitals administered anti-snake venom (ASV), 8.9% of patients received incomplete doses, highlighting the need for standardized protocols. Prolonged bite-to-needle time increases the risk of systemic envenomation, raising morbidity and mortality [21]. The high percentage of untreated patients in Uttarakhand underscores the urgent need for improved public health campaigns and infrastructure to ensure timely access to antivenom and life-saving treatments.

In our study, all hemotoxic snakebite patients had elevated bleeding time (BT) and clotting time (CT), consistent with Bhalla et al., Saini et al. [6, 9], and Anurekha et al. [13]. These parameters normalized within 3–4 days after receiving full doses of ASV and blood transfusions, with Anurekha et al. reporting quicker CT normalization (8.1 to 18 h). Hemotoxic bites also caused abnormal prothrombin time (PT), with an average activated partial thromboplastin time (APTT) of 33.65 s and PT/INR of 25.19/2.45 s.

Our study categorized snakebites based on symptoms rather than snake species, as many patients could not identify the snake, and in several cases, the bite was unwitnessed or could not be identified. Among 101 patients, 49 (48.5%) were asymptomatic, 32 (31.7%) had hemotoxic symptoms, and 16 (15.8%) exhibited neurotoxic symptoms. This aligns with studies where hemotoxic bites were most common (Biju et al. [22], Gopalakrishnan et al. [23]), though Patel et al. [24] reported more neurotoxic bites. The higher rate of asymptomatic cases may reflect regional species differences or better identification of non-venomous bites.

Consistent with Bhalla et al. [6], ptosis (16 cases, 100%) was the most common neurotoxic symptom, followed by ophthalmoplegia (14 cases, 88%), dysphagia, and respiratory paralysis (10 cases, 62.5%). Limb paralysis occurred in 6 cases (38%), and 2 patients (13%) had a Glasgow Coma Scale (GCS) < 8. Respiratory paralysis was identified by a breath count under 20, breath-holding time under 30 s, or inability to hold the neck against gravity. Krait bites in northern India have been linked to locked-in syndrome [25], and neurotoxicity from cobra and krait bites affects muscles involved in eye movement, swallowing, and breathing. Our study did not categorize envenomation severity, and no cases of delayed neurotoxicity were observed. Venom toxins cause neuromuscular blockade through presynaptic (beta-neurotoxins) and postsynaptic (alpha-neurotoxins) mechanisms, depleting acetylcholine vesicles or inhibiting acetylcholine binding [26, 27]. While regional variations in neurotoxic and hemotoxic bites have been reported, our findings do not support this pattern [28].

In our study, hemotoxic bites were the most common, accounting for 32 cases (31.7%). These bites, primarily from viper envenomation, presented with symptoms such as local bleeding (94%), gum bleeding (47%), hematuria (38%), hematemesis (28%), subconjunctival hemorrhage (3%), ecchymosis (3%), and intracranial bleeding (3%), consistent with previous studies [6]. Hemotoxic venoms disrupt coagulation, leading to venom-induced consumption coagulopathy (VICC) and depleting fibrinogen and coagulation factors II, V, VIII, and X. C-type lectins, disintegrins, and metalloproteinases contribute to thrombocytopenia [29].

Treatment followed the National Health Mission (NHM) guidelines [30], with up to 30 vials of anti-snake venom (ASV) for hemotoxic bites and 20 vials for neurotoxic bites. Patients with severe hemotoxic envenomation received 30 vials. We conducted clinical assessments and laboratory investigations, including coagulation tests, CBC, renal function, and electrolyte evaluations, in line with NHM protocols. Polyvalent ASV was administered intravenously, adjusted based on clinical response. Supportive care included blood products (fresh frozen plasma, platelets, cryoprecipitate), pain management, and fluid resuscitation.

For neurotoxic cases, treatment followed NHM guidelines, including ASV and measures for neuromuscular paralysis. Symptoms such as ptosis, diplopia, difficulty swallowing, and respiratory distress were managed with atropine (0.5–1 mg IV) for bradycardia and secretions, and neostigmine (0.5–1 mg IV) to reverse neuromuscular blockade, adjusted based on paralysis severity. In suspected krait bites, calcium gluconate (10–20 mL of 10% solution IV) was given to stabilize the neuromuscular junction. Supportive care included continuous monitoring of vital signs, respiratory and renal function, and mechanical ventilation for severe muscle weakness or respiratory failure. Fluid management, electrolyte correction, and pain relief with analgesics were also provided.

Acute kidney injury (AKI) was diagnosed in 17 patients (53%) using AKIN criteria [31]. Patients presented with oliguria and metabolic acidosis, with 7 (19%) requiring hemodialysis and 2 (6.3%) undergoing plasmapheresis. The correlation between AKI and the timing of ASV administration remains debated, though some studies suggest dark urine may indicate AKI [32]. Hemodialysis decisions followed National Health Mission guidelines [30]. Thrombotic microangiopathy (TMA), seen in patients with venom-induced consumption coagulopathy (VICC), resulted in microangiopathic hemolytic anemia and thrombocytopenia. TMA treatment typically involves hemodialysis, with recent studies suggesting plasmapheresis may offer additional benefits [33, 34]. The use of hemodialysis (19%) and plasmapheresis (6.3%) in our study aligns with Dhikav et al. [35], underscoring the importance of tertiary care. Plasmapheresis, a category III, grade 2 C recommendation by the American Society for Apheresis (ASFA), was used for snakebite-related TMA and diffuse alveolar hemorrhage [36–38].

In our study, 10 (62.5%) patients with neurotoxic snakebites required mechanical ventilation, with 5 (31.3%) needing it for over 48 h and 3 (18.8%) undergoing tracheostomy. One patient died from aspiration pneumonia, sepsis, and multiorgan dysfunction. These findings are consistent with Bhalla et al. [6], who reported a 71% mechanical ventilation rate, mostly for less than 24 h.

Spontaneous bleeding in hemotoxic envenomation was managed with FFP, RDP, or cryoprecipitate. Of 32 hemotoxic cases, 10 (31%) required blood components, including 4 (12.9%) with thrombotic microangiopathy who received packed red blood cells and platelets. One patient died from cerebral venous sinus thrombosis, and another succumbed to coagulopathy, sepsis, and septic shock after 5 days, consistent with previous studies [6]. Hypotension occurred in 10 (31%) patients, with 6 (19%) requiring vasopressors. The causes of shock in snake bite include blood loss, septic shock, or rarely hypopituitarism, which respond to glucocorticoid treatment [39–41].

Local complications, including cellulitis [5], necrotizing fasciitis [2], and compartment syndrome [1], were found in 8 (7.9%) patients, lower than in other studies. Of the 8 patients with local complications, 5 (62.5%) required surgical intervention, including fasciotomy or debridement, and 3 (37.5%) needed skin grafting. Compartment syndrome was identified by signs such as pale skin, weak pulses, tight swelling, severe pain, and loss of movement. Necrotizing fasciitis presented with flu-like symptoms, progressing to tissue redness, swelling, death, and sepsis [42, 43]. Imaging with ultrasound and CT scans facilitated early diagnosis. For persistent swelling, broad-spectrum antibiotics and magnesium sulfate compresses (2–3 times/day for 5–7 days) were used. Limb elevation showed uncertain effectiveness. Antivenom reversed coagulopathy and reduced edema, while corticosteroids were avoided. Severe cases required surgical referral for debridement and fasciotomy [44, 45].

Venom enzymes like hyaluronidase and phospholipase A2 cause edema, blistering, and tissue necrosis, with viper bites leading to bruising, blistering, and delayed necrosis. Incorrect practices, such as pressure bandages or irritants, can worsen damage. Timely surgical intervention is essential to prevent infection and preserve limb function. Hyperbaric oxygen therapy, used in 2 (6%) patients with hemotoxic bites, improved tissue oxygenation and healing, potentially reducing the need for fasciotomy [46].

In our study, 69 symptomatic patients (68.3%) received anti-snake venom (ASV), with 28 (40.6%) developing adverse reactions. The most common were fever, chills, and rigor (64.2%), followed by nausea and vomiting (46.4%) and itching (42.9%). Severe reactions, such as respiratory distress (17.9%) and anaphylactic shock (10.7%), were less frequent. High-risk individuals were closely monitored and given prophylactic hydrocortisone (200 mg) and chlorpheniramine (22.75 mg) before ASV, with 2 h of observation and epinephrine on standby. In case of adverse reactions, ASV infusion was stopped, and treatment with epinephrine (0.5 mg IM), chlorpheniramine (10 mg IV), and hydrocortisone (100–200 mg IV) was initiated. If no improvement occurred in 8 min, a second dose of epinephrine was given. ASV was slowly reinitiated once symptoms resolved. For severe anaphylaxis, a desensitization protocol was followed, and for pyrogenic reactions, chlorpheniramine and paracetamol were administered with close monitoring.

Given the critical nature of snakebite management in rural areas, our institution has focused on strengthening peripheral healthcare by training medical officers in community health centers (CHCs) to manage snakebites effectively. We organize annual Continuing Medical Education (CME) programs in alignment with International Snakebite Awareness Day to update medical officers on the latest treatment protocols, particularly timely anti-snake venom (ASV) administration. These sessions cover snake identification, symptom assessment, and early intervention strategies. Additionally, we collaborate with the Uttarakhand State Council for Science and Technology (UCOST) to host a toxicology conference, bringing together healthcare professionals, public health officials, and experts to discuss best practices and recent treatment advances. These initiatives aim to empower rural medical officers with the necessary skills to improve patient outcomes and support healthcare infrastructure.

In Uttarakhand, healthcare workers are crucial in managing snake envenomations due to the region's geographical challenges. Many remote areas lack advanced medical facilities, and trained professionals often serve as the first line of defense. The National Action Plan for Snake Envenoming (NAPSE) highlights the importance of specialized training for healthcare workers in snakebite recognition, ASV administration, and management of complications like coagulopathy and respiratory distress. NAPSE training is essential in Uttarakhand, where delayed treatment and low public awareness are common. Healthcare workers must also understand the region's terrain and transportation challenges to make informed decisions about patient transfers. By integrating NAPSE training, Uttarakhand can develop a network of skilled professionals capable of providing optimal care, regardless of location.

Conclusion

This study provides a detailed analysis of the clinical and demographic patterns of suspected snakebites in Uttarakhand and surrounding areas, offering valuable insights into local practices and response strategies. The findings highlight the critical importance of early recognition of envenomation, prompt initiation of treatment, and timely referral to advanced medical facilities to prevent fatalities. The administration of anti-snake venom (ASV) is identified as the most crucial intervention for saving lives. However, the widespread lack of awareness about the severity of snakebites and the urgency of timely treatment complicates effective management, particularly in rural areas with limited healthcare access.

The study emphasizes the urgent need for targeted public health initiatives in remote communities, where treatment delays are most prevalent. Public awareness campaigns that focus on the early recognition of snakebites, the importance of seeking immediate medical attention, and the critical role of ASV in preventing fatalities could significantly improve patient outcomes. Additionally, developing community-specific treatment protocols could equip local healthcare workers to manage snakebites more effectively, reducing the need for unnecessary referrals to distant medical centers.

Furthermore, the study sheds light on the potential complications of snake envenomation, such as respiratory paralysis, acute kidney injury, and coagulopathy, which often require advanced interventions like intubation, hemodialysis, and blood transfusions. Given the resource constraints in rural areas, it is essential for healthcare systems to strengthen referral pathways to facilitate the quick transfer of patients to higher-level facilities equipped with appropriate resources, accompanied by thorough referral documentation.

In conclusion, the findings from this study could serve as a foundation for the development of region-specific public health strategies aimed at reducing both the incidence and mortality associated with snakebites. By enhancing public awareness, improving access to treatment, and strengthening referral systems, healthcare systems can significantly reduce the burden of snakebites in rural populations, ultimately improving health outcomes in these vulnerable communities.

Limitations of the study

Our study has several limitations. Being single-centered, the findings are specific to a tertiary care hospital and may not be fully representative of other regions or healthcare settings. The lack of snake species identification limits venom-specific management insights, and variability in pre-hospital treatments, such as inconsistent tourniquet use and traditional practices, was noted but not evaluated for its impact. Many patients presented 12–24 h post-bite, potentially influencing outcomes and underestimating the benefits of early intervention. The study's limited sample size also restricted subgroup analyses, particularly between neurotoxic and hemotoxic bites. Additionally, long-term outcome assessments were not conducted, preventing insight into chronic complications. Generalizability is limited due to ecological and institutional differences, and patient recall may introduce bias. Preventive measures, like public education, were not thoroughly explored, which are essential in reducing snakebite incidents. Further, the lack of comparison with lower-level hospitals, such as Community Health Centers (CHCs), is another limitation. The study focused on cases treated at our tertiary center, which tends to handle more severe cases, leading to a higher venomous rate compared to peripheral settings, where less severe cases are managed initially. The limited transport facilities and underreporting of cases in remote areas of Uttarakhand further complicate drawing conclusive evidence regarding the clinicoepidemiological profile. These limitations suggest the need for larger, multicenter studies to validate and expand upon our findings.

Take home message

This study underscores the critical need for early recognition and prompt treatment of snake bites, particularly in rural areas where healthcare access is limited. The timely administration of anti-snake venom (ASV) is vital in preventing fatalities, but widespread lack of awareness complicates effective management. Targeted public health interventions, including education on snakebite identification and treatment, as well as improved referral systems, are essential to improving outcomes in these underserved communities. Strengthening local healthcare practices and creating accessible treatment protocols will be key in reducing snakebite-related mortality and morbidity.

Abbreviations

ASV	Anti Snake Venom
HBOT	Hyper Baric Oxygen Therapy
DIC	Disseminated Intravascular Coagulation
APTT	Activated Partial Thromboplastin Time
BT	Bleeding Time
CT	Clotting Time

Acknowledgements
Not applicable.

Author contributions
Conceptualization: N.K., M.D. Data curation: P.S., J.J., T.S., S.S., A.S., B.K, M.K.,P.M. Formal analysis: N.K., M.D. Methodology: N.K., M.D., P.S., P.M. Writing – original draft: P.S. Writing – review & editing: P.S., N.K., M.D., J.J., T.S., S.S., A.S., B.K, M.K., P.M.

Funding
There are no sources of funding to declare.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study was approved by the Institutional Ethics Committee, All India Institute of Medical Sciences, Rishikesh (Reference number- No. 286/IEC/IM/NF/2022).

Consent to participate
All patients enrolled in the study signed an informed written consent for the use and publication of their medical records for academic and research purposes.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 15 October 2024 / Accepted: 20 December 2024
Published online: 10 March 2025

References

1. World Health Organization. Snakebite envenoming India. Available from: https://www.who.int/india/health-topics/snakebite. Accessed August 21, 2024.
2. Chippaux JP, Massougbodji A, Habib AG. The WHO strategy for prevention and control of snakebite envenoming: a sub-saharan Africa plan. J Venom Anim Toxins Incl Trop Dis. 2019;25. https://doi.org/10.1186/s41120-019-0128-2.
3. Suraweera W, Warrell D, Whitaker R, Menon G, Rodrigues R, Fu SH, Begum R, Sati P, Piyasena K, Bhatia M, Brown P, Jha P. Trends in snakebite deaths in India from 2000 to 2019 in a nationally representative mortality study. eLife. 2020;9. https://doi.org/10.7554/eLife.54076.
4. Gutiérrez JM, Casewell N, Laustsen AH. Progress and challenges in the field of snakebite envenoming therapeutics. Annu Rev Pharmacol Toxicol. 2024;64:1–19. https://doi.org/10.1146/annurev-pharmtox-121623-092442.
5. Mongabay-India. Mapping snakes in Uttarakhand for safer coexistence with humans. Available from: https://india.mongabay.com/2020/05/mapping-snakes-in-uttarakhand-for-safer-coexistence-with-humans/. Accessed August 21, 2024.
6. Mhaskar D, Agarwal A, Bhalla G. A study of clinical profile of snake bite at a tertiary care centre. Toxicol Int. 2014;21(2):203–8. https://doi.org/10.4103/0971-6580.151658.
7. Bhat RN, Singh AB, Gupta S, Kumar R, Sharma P, Patel J. Viperine snake bite poisoning in Jammu. J Indian Med Assoc. 1974;63(12):383–92. https://doi.org/10.1038/s41598-019-56662-5.
8. Russell FE, Emery JA. Effects of corticosteroids on lethality of Ancistrodon contortrix venom. Am J Med Sci. 1961;241:507–11.
9. Saini RK, Sharma S, Singh S, Pathania NS. Snake bite poisoning: a preliminary report. J Assoc Physicians India. 1984;32(2):195–7.
10. Sarangi A, Jana I, Das JP. Clinical profile of snake bite poisoning. J Assoc Physicians India. 1977;25:55–60.
11. Satyanarayan B, Panda SK, Sunder A, Kumari S. Clinical and epidemiological profile of snakebite cases – A study from an industrial teaching hospital at Jamshedpur, Jharkhand, India. J Family Med Prim Care. 2022;11(12):7652–6. https://doi.org/10.4103/jfmpc.jfmpc_890_22.
12. Patil V, Patil H, Patil A, Agrawal V. Clinical Profile and outcome of envenomous snake-bite at tertiary care centre in western Maharashtra. Int J Med Public Health. 2011;1(4):28–38. https://doi.org/10.5530/ijmedph.4.2011.7.
13. Anurekha N, Paranthakan. A study of clinical profile of snake bite at a tertiary care centre. Panacea J Med Sci. 2024;14(1):255–9. https://doi.org/10.18231/j.pjms.2024.045.
14. Reid HA, Theakston RD. The management of snake bite. Bull World Health Organ. 1983;61(6):885–95.
15. Virmani SK, Dutt OP. A profile of snake bite poisoning in Jammu region. J Indian Med Assoc. 1987;85(5):132–4.
16. Vora DH, Vora JH. An Epidemiological Study of Venomous Snake Bites: a Hospital based analysis. Natl J Community Med. 2019;10(8):474–8.
17. Banerjee RN. Venomous snakes of India, their venoms, symptomatology and treatment of envenomation. Prog Clin Med India. 1978;2:136–79.
18. Rahman R, Faiz MA, Selim S, Rahman B, Basher A, Jones A. Annual incidence of snake bite in rural Bangladesh. PLoS Negl Trop Dis. 2010;4(10). https://doi.org/10.1371/journal.pntd.0000860.
19. Lal P, Dutta S, Rott SB, Dhanabalam M, Kumar A. Epidemiologicalprofile of snakebite.cases admitted in JIPMER hospital. Indian J CommunityMed. 2001;26:36–8.
20. Watt G, Padre L, Tuazon ML, Theakston RD, Laughlin LW. Tourniquet application after cobra bite: delay in the onset of neurotoxicity and the dangers of sudden release. Am J Trop Med Hyg. 1988;38(3):618–22. https://doi.org/10.4269/ajtmh.1988.38.618.
21. Jayaraman T, Dhanasinghu R, Kuppusamy S, Gaur A, Sakthivadivel V. Bite-to-needle time – an extrapolative indicator of repercussion in patients with snakebite. Indian J Crit Care Med. 2022;26(11):1175–8. https://doi.org/10.5005/jp-journals-10071-25667.
22. Biju AP, Krishnan J. Clinical and laboratory profile of snake bite envenomation: a crosssectional observational study at a tertiary care center. J Evid Based Med Healthc. 2018;5(40):2860–4. https://doi.org/10.18410/jebmh/2018/585.
23. Gopalakrishnan M, Saurabh S, Dutta TK. Clinical profile of viper envenomations in Kerala, India: some unanswered questions. Int J Gen Med. 2018;11:391–2. https://doi.org/10.2147/ijgm.s177509.
24. Patel S, Patel A, Ganjiwale J, Patel D, Nimbalkar S. The study of clinical profile and outcome of patients with snakebite in a rural community. J Family Med Prim Care. 2021;10(4):1661–5. https://doi.org/10.4103/jfmpc.jfmpc_1976_20.
25. Chauhan V, Thakur S. The north-south divide in snake bite envenomation in India. J Emerg Trauma Shock. 2016;9(4):151–4. https://doi.org/10.4103/0974-2700.194110.
26. Prasarnpun S, Walsh J, Awad SS, Harris JB. Envenoming bites by kraits: the biological basis of treatment-resistant neuromuscular paralysis. Brain. 2005;128(Pt 12):2987–96. https://doi.org/10.1093/brain/awh642.
27. Nirthanan S, Selvanayagam M, Charpantier E, Gopalakrishnakone P, Gwee M, Khoo HE. Candoxin, a novel toxin from Bungarus candidus, is a reversible antagonist of muscle (alpha, beta, gamma, delta) but a poorly reversible antagonist of neuronal alpha 7 nicotinic acetylcholine receptors. J Biol Chem. 2002;277(20):17811–20.

28. Sharma R, Dogra V, Sharma G, Chauhan V. Mass awareness regarding snake bite induced early morning neuroparalysis can prevent many deaths in North India. Int J Crit Illn Inj Sci. 2016;6(3):115–8. https://doi.org/10.4103/2229-5151.190652.
29. Slagboom J, Kool J, Harrison RA, Casewell NR. Haemotoxic snake venoms: their functional activity, impact on snakebite victims and pharmaceutical promise. Br J Haematol. 2017;177(6):947–59. https://doi.org/10.1111/bjh.14591.
30. Management of Snake Bite [Internet]. National Health Mission.[cited 2024 Dec 26]. Available from: https://nhm.gov.in/images/pdf/guidelines/nrhm-guidelines/stg/Snakebite_Full.pdf
31. Harshavardhan. A study on the acute kidney injury in snake bite victims in a tertiary care centre. J Clin Diagn Res. 2013;7(10):2248–51.
32. Paul J, Dasgupta S. Early prediction of acute kidney injury by clinical features of snakebite patients at the time of hospital admission. North Am J Med Sci. 2012;4(5):216–20. https://doi.org/10.4103/1947-2714.95903.
33. Prasad H, Kaeley N, Jose JR, Ajun, Shankar T, Salam A, Shukla K. (2024). The role of plasmapheresis in snake envenoming: a systematic review. In medRxiv. https://doi.org/10.1101/2024.09.27.24314476
34. Fouad MM, Zawilla NH, Abdelsamie AA, Manawil M, Shehata RSA, Mohammed RS, Khalifa EM, Ramadan A, M., Mourad BH. Successful management of severe unresponsive snake bite envenomation using plasmapheresis and corticosteroid at Egyptian national environmental and clinical toxicology research center: a case report. Wilderness Environ Med. 2024;35(1):82–7. https://doi.org/10.1177/10806032231225102.
35. Dhikav V, Gupta R, Saini J, Mandani P, Upadhyay P, Shakeel K, Menon J. Snakebites in three districts of rural areas of Western India during winter. Indian J Med Specialities. 2024. https://doi.org/10.4103/injms.injms_57_24.
36. Padmanabhan A, Connelly-Smith L, Aqui N, Schulman S, Knovich MA, Reddy V, et al. Guidelines on the use of therapeutic apheresis in clinical practice - evidence-based approach from the writing committee of the American Society for Apheresis: the eighth special issue. J Clin Apher. 2019;34:171–354. https://doi.org/10.1002/jca.21705.
37. Mohan G, Guduri PR, Shastry S. Role of therapeutic plasma exchange in snake bite associated thrombotic microangiopathy: a case report with review of literature. J Clin Apher. 2019;34:507–9. https://doi.org/10.1002/jca.21712.
38. Sakhuja V, Aggarwal A, Arora P, Soni KD, Gulia A, Rajeshwari. Plasmapheresis for pulmonary hemorrhage following viperine snakebite: case report with review of literature. Indian J Crit Care Med. 2020;24(10):986–90. https://doi.org/10.5005/jp-journals-10071-23533.
39. Gopalakrishnan M, Vinod KV, Dutta TK, Shaha KK, Sridhar MG, Saurabh S. Exploring circulatory shock and mortality in viper envenomation: a prospective observational study from India. QJM: Monthly J Association Physicians. 2018;111(11):799–806. https://doi.org/10.1093/qjmed/hcy175.
40. Bhattacharya S, Krishnamurthy A, Gopalakrishnan M, Kalra S, Kantroo V, Aggarwal S, Surana V. Endocrine and metabolic manifestations of snakebite envenoming. Am J Trop Med Hyg. 2020;103(4):1388–96. https://doi.org/10.4269/ajtmh.20-0161.
41. Rajagopala S, Thabah MM, Ariga KK, Gopalakrishnan M. Acute hypopituitarism complicating Russell's viper envenomation: case series and systematic review. QJM: Monthly J Association Physicians. 2015;108(9):719–28. https://doi.org/10.1093/qjmed/hcv011.
42. Sartelli M, Guirao X, Hardcastle TC, Kluger Y, Boermeester MA, Raşa K, Ansaloni L, Coccolini F, Montravers P, Abu-Zidan FM, Bartoletti M, Bassetti M, Ben-Ishay O, Biffl WL, Chiara O, Chiarugi M, Coimbra R, De Rosa FG, De Simone B, Catena F. (2018). 2018 WSES/SIS-E consensus conference: recommendations for the management of skin and soft-tissue infections. World Journal of Emergency Surgery, 13(1), 58. https://doi.org/10.1186/s13017-018-0219-9
43. Stevens DL, Bisno AL, Chambers HF, Dellinger EP, Goldstein EJC, Gorbach SL, Hirschmann JV, Kaplan SL, Montoya JG, Wade JC, Infectious Diseases Society of America. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the Infectious Diseases Society of America. Clin Infect Diseases: Official Publication Infect Dis Soc Am. 2014;59(2):e10–52. https://doi.org/10.1093/cid/ciu444.
44. Afroz A, Siddiquea BN, Chowdhury HA, Jackson TNW, Watt AD. Snakebite envenoming: A systematic review and meta-analysis of global morbidity and mortality. PLoS Neglected Tropical Diseases. (2024);18(4):e0012080. https://doi.org/10.1371/journal.pntd.0012080
45. (N.d.-c). Health.Mil. Retrieved December 26, 2024, from https://jts.health.mil/assets/docs/cpgs/Global_Snake_Envenomation_Management_30_Jun_2020_ID81.pdf
46. Korambayil PM, Ambookan PV, Abraham SV, Ambalakat A. A multidisciplinary approach with hyperbaric oxygen therapy improves outcome in snake bite injuries. Toxicol Int. 2015;22(1):104–9. https://doi.org/10.4103/0971-6580.172287.

Publisher's note