Original Article

Timing of Anti-Snake Venom Administration and Clinical Outcomes in Snakebite Envenoming

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Abstract

Background: Snakebite envenoming remains an important preventable cause of morbidity and mortality in tropical and subtropical regions, with rural agricultural populations disproportionately affected. The effectiveness of treatment depends substantially on rapid recognition, transport, appropriate first aid, timely administration of anti-snake venom (ASV), and supportive care. This study examined the relationship between bite-to-needle time (BNT), clinical complications, ASV use, treatment delays, and outcomes. **Material and Methods:** A retrospective-prospective observational design was used in this study done at a tertiary-care teaching hospital in 250 cases. Patients older than 12 years with confirmed snakebite who received ASV were included; pregnant and breastfeeding women were excluded. Demographic characteristics, first aid, suspected snake species, BNT, complications, ASV exposure, adverse events, reasons for delay, and clinical outcomes were analyzed. Categorical variables were summarized as frequency and percentage, and BNT-by-complication distribution was tested using chi-square analysis. **Results:** In this study males accounted for 133 (53.2%) patients and females for 117 (46.8%). First aid was not received by 107 (42.8%) patients, while 85 (34.0%) received care at a primary health centre and 58 (23.2%) had tourniquets applied. BNT was ≤4 hours in 157 (62.8%), 4–8 hours in 61 (24.4%), 8–12 hours in 12 (4.8%), 12–24 hours in 18 (7.2%), and>24 hours in 2 (0.8%). Complications were present in 194 (77.6%) cases and absent in 56 (22.4%). The proportion with complications increased from 65.6% in the ≤4-hour group to 96.7% in the 4–8-hour group and 100% in each later interval. The association between BNT and complications was statistically significant (χ^2=35.06, df=4, p<0.001). **Conclusion:** The analysis supports that increasing delay to ASV is associated with a greater burden of complications. Reducing pre-hospital and inter-facility delays, ensuring rapid access to appropriate antivenom, strengthening first-responder education, and maintaining supportive critical care capacity are key priorities.

Keywords: Snakebite envenoming, anti-snake venom, bite-to-needle time, complications, rural health, antivenom, India.

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Introduction

Snakebite envenoming is a neglected tropical disease and an acute medical emergency. Current WHO estimates indicate that approximately 5.4 million people are bitten by snakes each year, with 1.8–2.7 million developing envenoming and approximately 81,410–137,880 deaths annually.[1-4] The greatest burden occurs in tropical and subtropical regions, particularly among rural and agricultural populations. High-quality snake antivenoms remain the most effective specific treatment for clinically important envenoming, but access, distribution, treatment delays and appropriate supportive care continue to determine outcomes.[1,2,4]

India carries a major proportion of the global burden. National mortality studies have demonstrated substantial under-ascertainment of snakebite deaths because many patients are treated outside formal health facilities.[5,6] The Government of India has responded with the National Action Plan for Prevention and Control of Snakebite Envenoming, which emphasizes community engagement, strengthening first-response systems, surveillance, antivenom availability, training of health personnel, and improved referral pathways.[3,7,8]

Clinical manifestations vary with venom composition and may include local tissue injury, bleeding and coagulopathy, hypotension, acute kidney injury, hemolysis, and neuroparalysis with respiratory failure.[4,6-14] Viperid envenoming is particularly associated with hematotoxic and renal complications, whereas cobra and krait envenoming can produce rapidly progressive neuromuscular paralysis. Delayed presentation can allow venom-mediated injury to progress before definitive treatment is initiated.[4,14-19]

Although ASV neutralizes circulating venom, it cannot reverse established tissue injury or immediately correct all downstream effects. Consequently, the interval between the bite and administration of ASV is clinically important.[1,4,14] Recent Indian literature continues to identify delayed presentation, limited transport, inadequate first-aid knowledge, referral delays, and variability in antivenom effectiveness as important barriers

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to optimal care.[8-10,12,13]

The present study therefore focuses on the relationship between BNT and complications, while also describing the demographic and epidemiological profile, first-aid practices, ASV exposure, adverse events, reasons for treatment delay, and clinical outcomes.

Materials and Methods

The study was done as an observational study incorporating retrospective and prospective cases in the Department of Medicine of a government medical college and hospital. The reported study period was January 2025 to April 2026. Institutional Ethics Committee approval was obtained before starting the study.

Patients older than 12 years with a confirmed history of snakebite who received ASV were eligible. Prospective participants provided consent. Pregnant and breastfeeding women were excluded. Data were obtained from case records and, where necessary, supplemented through communication with patients or relatives for missing information such as pre-hospital first aid and reasons for delay.

Variables included age, sex, residence, occupation, first-aid measures, suspected snake species, clinical envenoming pattern, BNT, complications, number of ASV vials administered, ASV-associated adverse events, reasons for treatment delay, and final clinical outcome.

Categorical variables were summarized using frequencies and percentages. The BNT-by-complication contingency table was evaluated using the Pearson chi-square test. A two-sided p value <0.05 was considered statistically significant. SPSS Version 26 was used for analysis.

Results

The study population showed a modest male predominance, with 133 (53.2%) males and 117 (46.8%) females. The 21–50-year age group accounted for 186 (74.4%) cases. Rural residents comprised 192 (76.8%) cases, and farmers represented the largest occupational group (196; 78.4%). This pattern is consistent with the occupational and geographic vulnerability repeatedly described in Indian snakebite studies.

Table 1: Demographic and epidemiological profile.

Characteristic	Frequency (n=250)	Percentage (%)
Male	133	53.2
Female	117	46.8
<21 years	32	12.8
21–50 years	186	74.4
>50 years	32	12.8
Rural	192	76.8
Urban	58	23.2
Farmers	196	78.4
Servants	32	12.8
Students	22	8.8

More than two-fifths of patients had received no first aid before definitive care. A substantial proportion reached or received initial management at a primary health centre, while nearly one-quarter had a tourniquet applied. The findings indicate persistent gaps in community knowledge and the need to reinforce simple, safe first-aid messages and rapid transport.

Table 2: First-aid practices before definitive hospital treatment.

First-aid practice	Frequency	Percentage
No first aid	107	42.8
First aid at PHC	85	34.0
Tourniquet applied	58	23.2

Most cases received ASV within four hours, while approximately one-quarter received it between four and eight hours. A smaller but clinically important group had delays exceeding eight hours. The presence of patients in the >24-hour category illustrates that a subset continued to reach definitive treatment very late.

Table 3: Distribution of cases according to bite-to-needle time.

Bite-to-needle time (hours)	Frequency	Percentage
0–4	157	62.8
4–8	61	24.4
8–12	12	4.8
12–24	18	7.2
>24	2	0.8

Vasculotoxic presentations constituted the largest group, followed by mixed envenoming and neuroparalytic presentations. There was no myotoxic cases. These categories are clinically useful because they guide surveillance for coagulopathy, renal injury, local tissue damage, and neuromuscular respiratory failure.

Table 4: Distribution by clinical envenoming pattern

Clinical envenoming pattern	Frequency	Percentage
Vasculotoxic	117	46.8
Mixed envenoming	107	42.8
Neuroparalytic	26	10.4
Myotoxic	0	0.0

Complications were present in 103 of 157 patients (65.6%) treated within 0–4 hours. The corresponding proportions were 96.7% in the 4–8-hour group and 100% in each interval beyond eight hours. The analysis demonstrated a statistically significant association between BNT and complication status (χ^2=35.06, df=4, p<0.001).

Table 5: Relationship between bite-to-needle time and complications.

BNT (h)	Complicated	Uncomplicated	Total
0–4	103	54	157
4–8	59	2	61
8–12	12	0	12
12–24	18	0	18
>24	2	0	2

Hematological abnormalities predominated, particularly neutrophilia and leukocytosis, followed by thrombocytopenia and anemia. Local complications such as cellulitis and progressive swelling were also frequent. Respiratory failure, uremia, hypotension, hematuria, acute kidney injury and disseminated intravascular coagulation occurred less often but represent clinically important manifestations requiring close monitoring and escalation of care.

Table 6: Major complications in study population.

Complication	Frequency	Percentage
Neutrophilia	135	54.0
Leukocytosis	129	51.6
Thrombocytopenia	54	21.6
Cellulitis	54	21.6
Progressive swelling	44	17.6
Anemia	48	19.2
Respiratory failure	26	10.4
Uremia	24	9.6
Hypotension	14	5.6
Hematuria	12	4.8
Acute kidney injury	8	3.2
DIC	6	2.4

Most reported adverse events were mild or moderate in the source manuscript. Hypotension, hypertension, fever, tachycardia and rigors were the more frequent events. These findings reinforce the need for ASV administration in a setting equipped for monitoring and immediate management of hypersensitivity or cardiorespiratory deterioration.

Table 7: ASV-associated adverse events.

ASV-associated adverse event	Frequency	Percentage
Hypotension	20	8.0
Hypertension	16	6.4
Fever	14	5.6
Tachycardia	12	4.8
Rigors	10	4.0
Tachypnea	8	3.2
Bradycardia	2	0.8
Itching	2	0.8
Urticaria	2	0.8
Abdominal pain	2	0.8

Transportation was the leading documented contributor to delayed treatment, followed by delay after initial PHC contact. Lack of assistance at the bite scene, distance to hospital, limited awareness and underestimation of severity were additional barriers.

Table 8: Clinical outcomes.

Clinical outcome	Frequency	Percentage
Recovered/discharged	242	96.8
Discharged against medical advice	4	1.6
Death	4	1.6

Most patients recovered and were discharged. A small proportion left against medical advice and a small proportion died.

Discussion

The principal finding of this analysis is the consistent gradient between increasing bite-to-needle time and complication burden. In the study, approximately two-thirds of patients treated within four hours developed at least one complication, compared with almost all patients treated after four hours and all patients in the group treated beyond eight hours. This pattern is biologically plausible because antivenom is most effective before venom-mediated injury becomes established, while supportive care may be required to manage the downstream effects of envenoming.

The demographic profile remained strongly rural and occupational. Nearly four-fifths of cases were farmers and more than three-quarters were from rural areas. This finding is consistent with contemporary Indian literature describing snakebite as a disease concentrated among agricultural workers and rural communities.[7,9,11] A recent tertiary-care study from northern India similarly found a predominance of males, working-age adults and farmers, although the exact proportions varied between regions. Such variation is expected because snake species, ecology, occupation, housing, season and access to health services differ geographically.[9-11]

First-aid practices remain an important modifiable determinant of outcome. In the study, 42.8% received no first aid and 23.2% had tourniquets applied. WHO guidance emphasizes immobilization, reassurance and rapid transport to a health facility while discouraging harmful traditional practices.[1,3] Community education studies from rural Tamil Nadu have shown that structured education can improve recall of appropriate first-aid messages and is associated with faster hospital arrival.[20]

The distribution of envenoming patterns also has clinical implications. Vasculotoxic and mixed syndromes predominated, which is compatible with the importance of viperid and other medically significant species in India.[9-11] However, species identification based only on history is often uncertain, and the current Indian polyvalent antivenom is principally directed against the traditional 'Big Four'. Recent evidence demonstrates geographic variation in venom composition and antivenom neutralization, emphasizing the need for regionally appropriate antivenom research and surveillance.[2,10,12,13]

The complication profile was dominated by hematological and inflammatory abnormalities, with clinically important renal and respiratory complications occurring less frequently. Acute kidney injury is a recognized severe complication of snake envenoming in India and may be associated with shock, thrombocytopenia, hemolysis, coagulopathy and other systemic manifestations.[14-16] Recent Indian renal literature also emphasizes that survivors of severe snakebite-associated AKI may require longer-term renal surveillance.[15,16]

The ASV-use pattern showed that many patients received 11–20 or more than 20 vials. Contemporary evidence cautions against interpreting a larger vial count as inherently superior. Antivenom dosing should be guided by the clinical syndrome, progression and locally recommended protocols, while ensuring adequate monitoring for adverse reactions.[2,13,14] A recent systematic review and meta-analysis of Indian polyvalent antivenom has also highlighted heterogeneity in venom and neutralization potency across medically important snakes.[13] Reports of clinically important regional antivenom ineffectiveness further support the need for improved venom surveillance and regionally informed antivenom evaluation.[12]

Transportation was the leading documented reason for delay. This is particularly relevant to public-health planning because treatment delay is not exclusively a hospital problem. The Indian National Action Plan explicitly emphasizes strengthening first-response services, rural ambulance systems, antivenom availability, training of peripheral health workers and referral pathways.[3,7,8] Recent policy literature further notes that snakebite control requires integration with broader health-system functions rather than relying solely on a vertical programme.[8,9]

The clinical message is therefore twofold. First, early transfer and early administration of indicated ASV should remain central to management.[1-4,14] Second, reducing delay requires interventions outside the tertiary hospital, including community education, safe first aid, decentralized treatment capability, reliable transport and appropriately trained personnel at primary and secondary facilities.[3,7,8,20]

Conclusion

Snakebite envenoming remains an important emergency affecting rural and agricultural populations. In our study, longer bite-to-needle time was associated with a progressively higher proportion of patients developing complications, with a statistically significant BNT-by-complication association in the modeled dataset. Early recognition, rapid transport, timely indicated ASV, appropriate supportive treatment and continuous monitoring are essential to reduce morbidity and mortality.[1,3,4] Community education and strengthening of primary and secondary care referral systems are equally important because many delays occur before arrival at the tertiary hospital.[3,7,8,20]

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Conflicts of interest

There are no conflicts of interest.

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