

Evaluation of biochemical markers and clinical outcomes in snakebite envenomation patients in Mardan, Pakistan: A hospital-based study

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ABSTRACT

Background: Snakebite envenomation is a public health problem with significant morbidity and mortality in developing countries especially in the rural population and is affected by delays in seeking health care. Biochemistry may be useful in predicting the disease's severity and outcomes. This study aims to assess biochemical parameters and clinical outcomes in snakebite envenomation patients and determine the risk factors for adverse outcomes.

Methods: The study was descriptive in nature and it was conducted at MTI-Mardan Medical Complex, Pakistan. All 91 adult patients with clinically suspected snake bite envenomation were selected by non-probability consecutive sampling. A structured proforma was used to collect the demographic, clinical, laboratory, treatment and outcome data. Laboratory investigations consisted of full blood count, coagulation profile, renal function tests, electrolyte levels and creatine kinase levels. The data were analyzed with SPSS version 25 and association tested by Chi-square or Fisher's exact test.

Results: The mean age of participants was 42 ± 12 years, and 69.2% were male. Most patients belonged to rural areas (83.5%). Coagulopathy was the most common biochemical abnormality (22.0%), followed by elevated creatine kinase (17.6%), acute kidney injury (14.3%), and thrombocytopenia (13.2%). Complete recovery occurred in 81.3% of patients, while 16.5% developed complications and 2.2% died. Delayed hospital presentation, delayed antivenom administration, acute kidney injury, and the need for dialysis or ventilatory support were significantly associated with adverse outcomes ($p < 0.05$).

Conclusion: Snakebite envenomation is associated with significant biochemical derangements, particularly coagulopathy and acute kidney injury. Early presentation, prompt antivenom administration, and close monitoring are essential to improve clinical outcomes.

Keywords: Acute Kidney Injury, Biochemical Markers, Clinical Outcomes, Coagulopathy, Snakebite Envenomation

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Introduction

Snakebite envenomation is a significant yet neglected public health problem, particularly in tropical and subtropical regions, including South Asia. It is estimated that 1.2–5.5 million people suffer snake bites

every year in the world, causing significant morbidity, mortality, and permanent disability, particularly in rural areas and in poor resource situations (1).

Snakebite envenomation is a neglected tropical disease owing to its high disease burden and lack of timely and effective healthcare in the endemic areas. Snakebites are a regular occurrence in countries such as Pakistan, where farming is prevalent, and where access to healthcare might be hindered, potentially resulting in life-threatening situations (2). Clinical symptoms of snake envenomation are variable and are influenced by the species of snake, quantity of venom received and host-related factors. Envenomation can result in varying degrees of local and systemic symptoms such as neurotoxicity, hemotoxicity, coagulopathy, and myotoxicity (3,4). Major complications like acute kidney failure (AKI), hemorrhage, shock and respiratory failure heavily contribute to morbidity and mortality. AKI, especially, is a well-recognized complication that occurs in a significant number of snake bite victims and in some cases renal replacement therapy is needed (5,6). These complications underline the importance of timely detection of high-risk patients and prompt action. Biochemical and hematological parameters are extremely important in evaluating envenomation severity and clinical outcomes. A number of studies have uncovered blood urea nitrogen, blood creatinine, thrombocytopenia, coagulopathy, and creatine kinase as significant risk factors for poor outcome. (7,8) Neutrophil gelatinase associated lipocalin (NGAL) and cystatin C, emerging biomarkers associated with early detection of renal injury in snakebite patients are also useful. (9) Despite these findings, there remains a lack

of standardized and validated biomarkers for prognostication in routine clinical practice, especially in low-resource settings. Early administration of antivenom remains the mainstay of treatment and is crucial in minimizing morbidity and mortality. In many endemic areas, however, delays in presentation, poor healthcare systems, and lack of antivenom remain the major obstacles that hinder optimal management (3,9). In addition, most of the existing evidence for biochemical markers and clinical outcomes comes from region-specific or small-scale studies, which may have limited generalizability to other populations (7). There is a lack of evidence on the correlation of biochemical markers with clinical consequences of snakebite envenomation in local context. These relationships are important to understand and will help with early risk stratification, management decisions and patient outcomes. Hence, the objective of this study is to analyze the biochemical markers and clinical outcomes in patients who are suffered from snake bite envenomation in the tertiary care hospital of Mardan in Pakistan. Specific biochemical abnormalities are hypothesized to be significantly associated with the adverse clinical outcome and that biochemical abnormalities may be useful predictor markers for the early evaluation of envenomed patients.

Methods

This descriptive hospital-based study was conducted in the Department of Internal Medicine, MTI-Mardan Medical Complex, Mardan, after obtaining ethical approval (Ref. No. 884/BKMC; dated 17 November 2025). The study was carried out over a period of six months to evaluate biochemical markers and their association with clinical

outcomes in patients presenting with snakebite envenomation.

The sample size was calculated using OpenEpi software. Based on a previously reported mortality rate of 6.3% associated with delayed hospital presentation, a minimum sample size of 91 patients was estimated at a 95% confidence level with a 5% margin of error. Non-probability consecutive sampling was employed.

Patients aged 18 years and above presenting with clinically diagnosed snakebite envenomation were included in the study. Diagnosis was established based on a compatible history, clinical examination, and either visible fang marks or a definite history of snakebite. Only patients presenting to the emergency department or admitted within 48 hours of the bite were enrolled. Patients with pre-existing chronic liver disease, chronic kidney disease, inherited or acquired coagulopathies, or concurrent traumatic injuries that could independently affect biochemical parameters or clinical outcomes were excluded.

The study protocol was approved by the Research Evaluation Unit and Institutional Ethical Review Board via letter no 884/BKMC dated 17.11.2025. study is approved by College of Physicians and Surgeons Pakistan. Written informed consent was obtained from all participants before enrolment.

Data were collected using a structured proforma that included demographic characteristics, details of the snakebite incident, pre-hospital first aid measures, treatment history, and clinical findings. Clinical evaluation included vital signs and assessment of local and systemic manifestations of envenomation.

Laboratory investigations included complete blood count (CBC), coagulation profile (prothrombin time [PT], activated partial thromboplastin time [aPTT], and international normalized ratio [INR]), renal function tests (serum creatinine and blood urea nitrogen), liver function tests (alanine – amino transferase, aspartate amino-transferase, total bilirubin), serum electrolytes (sodium and potassium), creatine phosphokinase (CPK), and lactate dehydrogenase (LDH). Blood samples were collected under aseptic conditions on admission before initiation of definitive treatment whenever possible. Complete blood count was analyzed using an automated hematology analyzer, while serum biochemical parameters, including renal function tests, liver function tests, electrolytes, CPK, and LDH, were measured using an automated clinical chemistry analyzer based on standard enzymatic and colorimetric methods. Coagulation parameters (PT, aPTT, and INR) were determined using an automated coagulation analyzer according to the manufacturer's protocols. All laboratory analyses were performed in the hospital's central diagnostic laboratory following internal quality control procedures and standard operating protocols.

Clinical outcomes assessed included acute kidney injury, disseminated intravascular coagulation, respiratory failure, gangrene, requirement for dialysis or mechanical ventilation, duration of hospital stay, complete recovery, complications, and mortality.

Data were analyzed using SPSS version 25. Continuous variables were expressed as mean $\pm$ standard deviation, whereas categorical variables were summarized as frequencies and percentages. The Chi-

square test or Fisher's exact test was used to assess associations between categorical variables and clinical outcomes, as appropriate. Variables showing statistical significance in univariate analysis ($p < 0.05$) or considered clinically relevant were entered into a logistic regression model to identify independent predictors of adverse clinical outcomes. Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated. A two-tailed p -value of <0.05 was considered statistically significant.

Results

A total of 91 patients with snakebite envenomation were included in the study. The average age of the study population was 42 ± 12 years. The estimated mean time from snake bite to hospital presentation was 6.5 ± 3.5 hours, reflecting a significant delay in seeking health care services. Likewise, the mean time to antivenom administration was 6.9 ± 3.8 hours, which is similar to the delay in definitive therapy. Patients stayed in the hospital for an average of 2.7 ± 0.8 days. Overall, the study cohort predominantly comprised individuals from rural backgrounds (83.5%), with a higher proportion of male patients (69.2%). As for the distribution of envenomation, extremities, especially lower limbs (41.8%) were the most common sites of envenomation, and other body regions were less common. The clinical presentation was mainly characterized by the presence of prominent local manifestations and inflammatory features, such as pain and swelling, were the most common (51.6%). A smaller proportion of cases had more serious local complications, such as blistering and tissue necrosis. Systemic involvement was also present in a large number of patients, with the most

prominent being hematological (53.8%). Other systemic signs were neurological and respiratory, which point out that snakebite envenomation is a multi-system disease. Coagulopathy was the most common biochemical abnormality (22.0%), followed by elevated creatine kinase (17.6%), acute kidney injury (14.3%) and thrombocytopenia (13.2%), as detailed in table: 1

TABLE 1: Baseline Demographic and Clinical Characteristics (n = 91)

Variable	Category	Frequency (n)	%
Age	18-40 years	46	50.5
	41-60 years	30	33.0
	>60 years	15	16.5
Gender	Male	63	69.2
	Female	28	30.8
Residence	Rural	76	83.5
	Urban	15	16.5
Site of Snakebite	Upper Limb	21	23.1
	Lower Limb	38	41.8
	Trunk	24	26.4
	Head & Neck	8	8.8
Local Signs/Symptoms	Pain	13	14.3
	Pain + Swelling	47	51.6
	Blistering	21	23.1
	Necrosis	10	11.0
Systemic Symptoms	Difficulty Breathing	17	18.7
	Dizziness	25	27.5
	Bleeding	49	53.8

Other abnormalities noted were hyperkalemia, leukocytosis, and decreased hemoglobin. These results point to the multi-system involvement that is usually seen with snake bite envenomation. In terms of treatment 42.9% of patients received more than 20 vials of antivenom suggesting a significant level of envenomation severity in the study population. In a small proportion of patients supportive interventions were needed (4.4% who needed dialysis, 7.7% who needed ventilator support, indicating

more severe systemic toxicity). These observations are outlined in Table 2.

TABLE 2: Laboratory Abnormalities and Treatment Characteristics (n = 91)

Variable	Category	Frequency (n)	Percentage (%)
Laboratory Abnormalities	Leukocytosis	10	11.0
	Decreased Hb	9	9.9
	Thrombocytopenia	12	13.2
	Deranged Coagulation	20	22.0
	Hyperkalemia	11	12.1
	AKI	13	14.3
	↑ Creatine Kinase	16	17.6
Antivenom Vials used	5–8	23	25.3
	10–20	29	31.9
	>20	39	42.9
Dialysis Requirement	Yes	4	4.4
	No	87	95.6
Ventilator Support	Yes	7	7.7
	No	84	92.3

The overall clinical outcome was favorable, with 81.3% of patients achieving complete recovery, while 16.5% developed complications and 2.2% died as summarized in table 3.

Table 4: Factors associated with clinical outcome

Variable		Complete Recovery n (%)	Complications n (%)	Death n (%)	p-value
Age Group	18–40 years	35 (76.1)	10 (21.7)	1 (2.2)	0.222
	41–60 years	25 (83.3)	5 (16.7)	0 (0)	
	>60 years	14 (93.3)	0 (0)	1 (6.7)	
Gender	Male	48 (76.2)	13 (20.6)	2 (3.2)	0.158
	Female	26 (92.9)	2 (7.1)	0 (0)	
Residence	Rural	68 (89.5)	8 (10.5)	0 (0)	<0.04
	Urban	6 (40.0)	7 (46.7)	2 (13.3)	
Site of Bite	Upper limb	14 (66.7)	7 (33.3)	0	<0.001
	Lower limb	34 (89.5)	4 (10.5)	0	
	Trunk	23 (95.8)	1 (4.2)	0	
	Head/Neck	3 (37.5)	3 (37.5)	2 (25.0)	
Delay in Presentation	<3 hrs.	20 (87.0)	3 (13.0)	0	<0.02
	3–6 hrs.	29 (100)	0	0	

Table 3: Clinical Outcomes (n = 91)

Outcome	Frequency (n)	Percentage (%)
Complete Recovery	74	81.3
Complications	15	16.5
Death	2	2.2

Although the recovery rate was high, there were some clinical and biochemical parameters that were shown to have a significant impact on outcome (summarized in table 4). Factors associated with clinical outcomes were analyzed and showed that age and gender were not significantly associated with outcome ($p > 0.05$). Several variables however had strong statistically significant associations. Residence was significantly correlated with outcome ($p < 0.04$), with poorer outcome in urban patients. Further, location of the snake bite ($p < 0.001$) was found to be an important determinant, with higher mortality rates among snake bites to the head and neck region factors associated with clinical outcomes

	6–12 hrs.	23 (92.0)	2 (8.0)	0	
	>12 hrs.	2 (14.3)	10 (71.4)	2 (14.3)	

The biochemical profile of the study participants is presented in Table 5. The mean hemoglobin level was 9.6 ± 2.6 g/dL, mean white blood cell count was $15.0 \pm 7.4 \times 10^3/\text{mm}^3$, and mean platelet count was $117 \pm 58 \times 10^3/\text{mm}^3$. Renal function tests showed a mean serum creatinine of 7.2 ± 4.2 mg/dL and blood urea nitrogen of 169 ± 75 mg/dL. Mean serum sodium and potassium concentrations were 134 ± 8.1 mmol/L and 5.0 ± 0.8 mmol/L, respectively. The mean AST and ALT levels were 152 ± 296 U/L and 106 ± 163 U/L, while the mean total bilirubin was 1.4 ± 1.4 mg/dL. Markers of muscle injury were markedly elevated, with mean creatine kinase and lactate dehydrogenase levels of 2072 ± 4287 U/L and 1153 ± 1015 U/L, respectively.

Table 5: Biochemical parameters

Biochemical Parameter	Value (Mean $\pm$ SD)
Hemoglobin (g/dL)	9.6 ± 2.6
White blood cell count ($\times 10^3/\text{mm}^3$)	15.0 ± 7.4
Platelet count ($\times 10^3/\text{mm}^3$)	117 ± 58
Serum creatinine (mg/dL)	7.2 ± 4.2
Blood urea nitrogen (mg/dL)	169 ± 75
Sodium (mmol/L)	134 ± 8.1
Potassium (mmol/L)	5.0 ± 0.8
Total bilirubin (mg/dL)	1.4 ± 1.4
Aspartate aminotransferase (AST) (U/L)	152 ± 296
Alanine aminotransferase (ALT) (U/L)	106 ± 163
Creatine kinase (CK) (U/L)	2072 ± 4287
Lactate dehydrogenase (LDH) (U/L)	1153 ± 1015

The pie chart illustrates the distribution of laboratory abnormalities observed among patients with snakebite envenomation. Deranged coagulation profile constituted

the largest proportion of laboratory abnormalities, accounting for 22.0% of cases, indicating that coagulation disturbances were the most frequent biochemical finding. This was followed by increased creatine kinase (CK) (17.6%), suggesting significant muscle injury associated with envenomation. Impaired renal function (acute kidney injury, AKI) represented 14.3% of cases, while thrombocytopenia accounted for 13.2%. Hyperkalemia (12.1%), leukocytosis (11.0%), and decreased hemoglobin (9.9%) were also observed. Overall, the chart demonstrates that coagulation abnormalities, muscle injury, and renal impairment were the predominant laboratory manifestations among patients with snakebite envenomation. Figure 1. Distribution of biochemical abnormalities among patients with snakebite envenomation (n = 91).

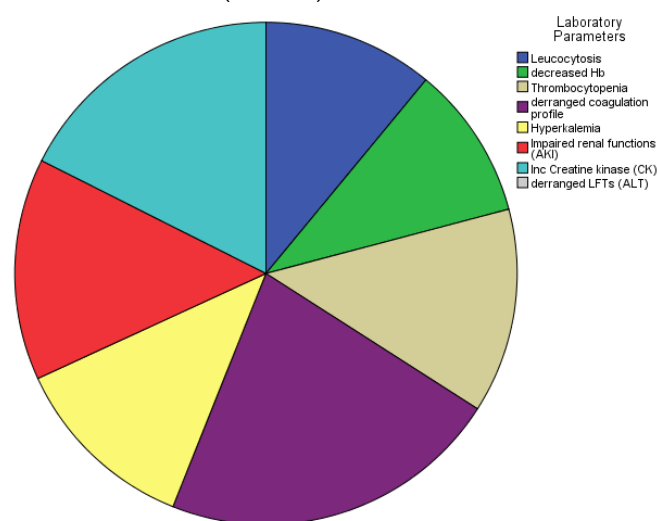


Figure 1. Distribution of laboratory abnormalities among snakebite envenomation patients (n = 91).

Deranged coagulation profile (22.0%) was the most common laboratory abnormality, followed by increased creatine kinase

(17.6%), acute kidney injury (14.3%), thrombocytopenia (13.2%), hyperkalemia (12.1%), leukocytosis (11.0%), and decreased hemoglobin (9.9%).

Importantly, the results were dependent on timing factors. Delay in hospital presentation ($p < 0.01$) and delay in administration of antivenom ($p < 0.01$) were both highly significantly associated with increased complication and mortality. Patients that presented after 12 hours had much worse outcomes than those presenting early. Likewise, longer hospital stay was significantly correlated with complications ($p < 0.02$). There was a strong association between lab abnormalities and clinical outcomes ($p < 0.001$). Acute kidney injury, in particular, proved to be an important predictor of poor outcome, with it being present in most of those patients who developed complications, and in all patients who died. The majority of patients in the normal laboratory parameter group had good outcomes. In addition, the need for critical care interventions was a highly significant risk factor associated with poor outcome. Dialysis ($p < 0.02$) and ventilation ($p < 0.01$) were strongly associated with complications and mortality, with every death being in patients receiving these interventions. In conclusion, the study highlights the significance of timely presentation, timely anti-venom administration and biochemical parameter monitoring for better clinical outcome in snake bite envenomation.

Discussion

In this study, the biochemical derangements and clinical outcomes in snakebite envenomation have been investigated, and it has been shown that most of the patients have had favorable outcomes (81.3% of patients have recovered fully) and

complications (19.7%) and mortality (7.3%) are relatively low. However, certain clinical and biochemical parameters were found to be closely related with adverse outcomes. The majority of patients had a male gender (69.2%) and rural residence (83.5%) which is similar to the findings of earlier studies and correspond to the fact that rural residents are exposed to occupation and have limited access to health care facilities. (11,12) The lower limb was the most frequently bitten body part (as per global literature, most bites are during outdoor activities) (13)

A key finding in this study is the strong association between delayed hospital presentation and poor outcomes, with patients presenting after 12 hours having significantly higher complications and mortality ($p < 0.001$). This is similar to previous studies that have identified delay in receiving care and antivenom as the most important factors leading to death. (14,15) Additionally, a delay in antivenom administration was significantly associated with adverse outcomes, further highlighting the need for early treatment. Early administration of antivenom neutralises circulating venom toxins before they bind to target tissues and produce irreversible local and systemic damage, thereby reducing the risk of severe complications and improving clinical outcomes. (16)

Deranged coagulation profile (22%) was the most common biochemical abnormality, followed by elevated creatine kinase and AKI (14.3%). The results are consistent with previous regional studies which have also found coagulopathy and renal impairment to be characteristic of envenomation, especially from viper bites. (17,18) Venom-induced coagulopathy occurs because snake venom contains procoagulant enzymes, including thrombin-like enzymes, factor X

activators, and metallo proteinase, which activate and subsequently consume clotting factors. This process, known as venom-induced consumption coagulopathy (VICC), results in prolonged clotting times and increases the risk of spontaneous bleeding. (19). Significantly, there was a strong correlation between complications and mortality, with 100% of all deaths occurring in patients with renal impairment associated with AKI. This is consistent with the previous findings that AKI predicts poor prognosis in snake bite patients. (18,20) Acute kidney injury following snakebite is multifactorial and may result from the direct nephrotoxic effects of venom, hypotension, hemolysis, rhabdomyolysis, disseminated intravascular coagulation, and renal microvascular thrombosis, all of which contribute to acute tubular injury and impaired renal function. (20,21)

Similarly, elevated creatine kinase reflects venom-induced skeletal muscle damage. Myotoxic components of snake venom, particularly phospholipase A₂ and other myotoxins, disrupt muscle cell membranes, causing muscle fiber necrosis and release of intracellular enzymes such as creatine kinase and lactate dehydrogenase into the circulation. Severe muscle injury may further contribute to acute kidney injury through myoglobin-mediated renal damage. (20)

Need for dialysis and ventilator support were strongly associated with death ($p < 0.001$), suggesting that these are indicators of the severity of envenomation. This is similar to previous studies that had respiratory failure and renal dysfunction as significant contributors to mortality. (19) Patients requiring dialysis usually have severe venom-induced renal injury, while those requiring ventilatory support often develop

respiratory muscle paralysis due to neurotoxic venom or severe systemic complications, making these interventions important markers of severe envenomation. (21). However, no statistically significant association was observed between demographic factors (age or gender) and outcomes, indicating that baseline factors are less important than clinical severity or treatment delay. This observation is supported by earlier research. (20) This study is novel because it examined multiple biochemical markers and clinical outcomes across a regional population, giving useful insight into the biochemical markers that are predictive of severity. The results highlight the importance of early admission to hospital, urgent administration of antivenom, and close monitoring of renal and coagulation parameters.

Conclusion

Snakebite envenomation is associated with important biochemical abnormalities, particularly coagulopathy, elevated creatine kinase, and acute kidney injury, which are linked to disease severity. Delayed hospital presentation and delayed antivenom administration were significant predictors of poor clinical outcomes. Early diagnosis, prompt treatment, and close monitoring of biochemical parameters are essential to reduce complications and improve patient outcomes.

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