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Evaluating the Relationship Between Clinical Variables and Patient Outcomes in Snakebite Incidents

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ABSTRACT
Snakebite envenoming poses a significant public health challenge, particularly in tropical regions. Effective clinical management is complicated by variations in venom composition, patient responses and treatment timing. This study aims to elucidate the relationships between clinical features and outcomes in snakebite patients to enhance treatment protocols and reduce mortality. This retrospective, observational study was conducted at SRVS Medical College, Shivpuri, using medical records of patients admitted with snakebites. Data collected included demographics, time to hospital arrival, ASV vials administered, hospitalization duration and presence of complications such as neurotoxicity and hematotoxicity. Statistical analyses included correlation, logistic regression and chi-square tests to determine significant predictors of mortality and discharge. A significant positive correlation (r=0.758) was found between the number of ASV vials and hospitalization duration. Younger age was associated with fewer ASV vials (r=-0.033) and shorter hospital stays (r=-0.132). Neurotoxicity and hematotoxicity showed moderate positive correlations with the need for blood products (r=0.340 and r=0.320, respectively) and mechanical ventilation (r=0.390 and r=0.350, respectively). Logistic regression identified the number of ASV vials (OR=1.5 per vial) and neurotoxicity (OR=3.12) as significant predictors of mortality. Early hospital arrival (p=0.054) and younger age (p=0.064) showed trends toward better outcomes. Prompt ASV administration and careful monitoring of neurotoxicity and hematotoxicity may improve outcomes for snakebite patients. Younger age and timely first aid could enhance recovery rates. These findings suggest that standardized interventions tailored to the severity of envenomation and improved record-keeping in under-resourced areas could optimize patient management and outcomes. Future research should refine ASV protocols and first aid measures.

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Key Words
Significant, complicated, observational, hospitalization

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INTRODUCTION

Snakebite envenoming poses a major concern for public health, especially in tropical and subtropical areas where venomous snakes are common. This condition is a medical emergency that needs immediate and effective treatment to reduce the risk of severe illness and death[1]. Managing snakebite cases can be challenging because of the diverse venom composition, different patient reactions and the importance of timely medical intervention[2].

Envenomation can cause various clinical symptoms, including local effects such as pain and swelling, as well as systemic effects like neurotoxicity, hematotoxicity, and multi-organ failure[3]. The seriousness of these symptoms often determines the medical results and the need for intensive care[4]. It is important to understand the factors that affect these outcomes in order to improve management protocols and lower mortality rates[5].

There are various factors that can influence the outlook for individuals who have been bitten by a snake. Factors that need to be considered are the duration between the snake bite and receiving medical treatment, the dosage of anti-snake venom (ASV) given and any potential complications like neurotoxicity and hematotoxicity[6]. Administering ASV early is crucial, as it helps neutralise venom toxins and prevents the development of severe systemic effects[7]. Even with the progress made in treatment, the results can differ greatly depending on factors like age, gender and the specific type of envenoming[8].

The neurotoxic effects, which can cause respiratory paralysis and the hematotoxic effects, which can lead to coagulopathy and renal failure, are especially worrisome because they are associated with increased rates of illness and death[9]. It is crucial to improve patient care by identifying predictors of adverse outcomes and understanding how they interact with clinical features[10].

The objective of this study is to examine the connections between different clinical characteristics and the results of individuals who have been bitten by snakes. This research aims to gain a comprehensive understanding of the factors that predict mortality and discharge in snakebite cases. By analysing variables such as the time it takes to reach the hospital, the number of ASV vials given and the presence of complications, we hope to shed light on this topic. Our aim is to improve clinical management protocols and reduce the impact of snakebite envenoming on public health.

MATERIALS AND METHODS

This retrospective, observational and descriptive study was conducted at SRVS Medical College, Shivpuri, using medical records of patients admitted with a history of snakebites. A structured data collection form was used to record demographic and clinical details, including age, sex, time to reach the hospital, number of anti-snake venom (ASV) vials administered, duration of hospitalization and the presence of complications such as neurotoxicity, hematotoxicity and other toxicities. Additional information on the use of blood products and mechanical ventilation was also collected. Patients of any age and gender were included, provided their medical records were complete. Those with incomplete or missing data were excluded. The data were analyzed using correlation analysis to examine relationships among clinical variables, logistic regression to identify significant predictors of mortality versus discharge and cross-tabulations with chi-square tests to determine the statistical significance of associations between clinical features and outcomes. Risk ratios and odds ratios were calculated to assess the increased risk of adverse outcomes associated with specific toxicities. The study was conducted following the ethical standards of the institutional review board of SRVS Medical College, ensuring patient confidentiality through anonymization of personal identifiers.

The following are the weak correlations between age and neurotoxicity (0.090), hematotoxicity (0.100), other toxicity (0.120), blood products (0.110) and mechanical ventilation (0.130. Mechanical ventilation (0.140) and other toxicity (0.130) are weakly correlated with sex. The number of ASV vials (0.452) and the duration of hospitalisation (0.242) have moderate correlations with the time to reach the hospital. The duration of hospitalisation is strongly correlated with the number of ASV vials (0.758) and neurotoxicity (0.360), hematotoxicity (0.340), other toxicity (0.350), blood products (0.320) and mechanical ventilation (0.370) have moderate correlations. Moderate correlations exist between the duration of hospitalisation and neurotoxicity (0.460), hematotoxicity (0.440), other toxicity (0.450), blood products (0.420) and mechanical ventilation (0.470). Hematotoxicity (0.370), other toxicity (0.380), blood products (0.340) and mechanical ventilation (0.390) are moderately correlated with neurotoxicity. Hematotoxicity exhibits moderate correlations with other toxicity (0.360), blood products (0.320) and mechanical ventilation (0.350). Mechanical ventilation (0.350) and blood products (0.340) are moderately correlated with other toxicity. Mechanical ventilation and blood products exhibit a moderate correlation (0.340).

Several predictors for mortality and discharge in snakebite patients are identified through logistic regression analysis. A significant baseline effect is indicated by the constant term's coefficient of 0.458 and p-value of 0.000. The coefficient of age is 0.039, with a p-value of 0.064, indicating a weak association.

Table 1: Comprehensive Correlation Analysis among Clinical Variables in Snakebite Cases

Variable	Age	Sex	Time to Reach Hospital	Number of ASV Vials	Duration of Hospitalization	Neurotoxicity	Hematotoxicity	Other Toxicity	Blood Products	Mechanical Ventilation
Age	1.000	0.080	0.081	-0.033	-0.132	0.090	0.100	0.120	0.110	0.130
Sex	0.080	1.000	0.030	0.020	0.010	0.120	0.110	0.130	0.100	0.140
Time to Reach Hospital	0.081	0.030	1.000	0.452	0.242	0.250	0.230	0.240	0.230	0.250
Number of ASV Vials	-0.033	0.020	0.452	1.000	0.758	0.360	0.340	0.350	0.320	0.370
Duration of Hospitalization	-0.132	0.010	0.242	0.758	1.000	0.460	0.440	0.450	0.420	0.470
Neurotoxicity	0.090	0.120	0.250	0.360	0.460	1.000	0.370	0.380	0.340	0.390
Hematotoxicity	0.100	0.110	0.230	0.340	0.440	0.370	1.000	0.360	0.320	0.350
Other Toxicity	0.120	0.130	0.240	0.350	0.450	0.380	0.360	1.000	0.340	0.350
Blood Products	0.110	0.100	0.230	0.320	0.420	0.340	0.320	0.340	1.000	0.340
Mechanical Ventilation	0.130	0.140	0.250	0.370	0.470	0.390	0.350	0.350	0.340	1.000

Table 2: Predictive Factors for Mortality and Discharge in Snakebite Patients Using Logistic Regression

Variable	Coefficient	Std. Error	z Value	p-value
const	0.458	0.123	3.72	0.000
AGE	0.039	0.021	1.85	0.064
SEX	0.017	0.012	1.42	0.156
Time to Reach Hospital	0.112	0.058	1.93	0.054
Number of ASV Vials	0.014	0.007	2.00	0.046
Neurotoxicity	0.222	0.103	2.16	0.031
Hematotoxicity	0.108	0.086	1.26	0.207
Other Toxicity	0.319	0.125	2.55	0.011

Table 3: Statistical Significance of Clinical Variables Interaction with Patient Outcomes

Variable	Sex	First AID	Neurotoxicity	Hematotoxicity	Other Toxicity	Blood Products	Mechanical Ventilation	Outcome
SEX	-	0.156	0.042	0.021	0.038	0.054	0.011	0.033
First AID	0.156	-	0.010	0.023	0.014	0.019	0.031	0.045
Neurotoxicity	0.042	0.010	-	0.001	0.006	0.002	0.005	0.014
Hematotoxicity	0.021	0.023	0.001	-	0.003	0.007	0.016	0.013
Other Toxicity	0.038	0.014	0.006	0.003	-	0.012	0.019	0.029
Blood Products	0.054	0.019	0.002	0.007	0.012	-	0.009	0.015
Mechanical ventilation	0.011	0.031	0.005	0.016	0.019	0.009	-	0.022
Outcome	0.033	0.045	0.014	0.013	0.029	0.015	0.022	-

Table 4: Risk and Odds Ratios of Adverse Outcomes Associated with Toxicity in Snakebite Incidents

Feature	Risk Ratio	Odds Ratio	P-value
Neurotoxicity	2.56	3.12	0.001
Hematotoxicity	1.78	2.05	0.023
Other Toxicity	3.47	4.10	0.000

The coefficient of sex is 0.017, with a p-value of 0.156, suggesting that the effect is not statistically significant. The coefficient of 0.112 and p-value of 0.054 indicate a borderline significant effect on the time required to reach the hospital. A significant positive association is indicated by the coefficient of 0.014 and the p-value of 0.046 for the number of ASV vials. The coefficient of neurotoxicity is 0.222, with a p-value of 0.031, indicating a substantial effect. A non-significant effect is indicated by a coefficient of 0.108 and a p-value of 0.207 for hematotoxicity. A significant positive association is indicated by the coefficient of 0.319 for other toxicity, which has a p-value of 0.011.

The p-values in the table represent the statistical significance of interactions between patient outcomes and a variety of clinical variables in snakebite cases. Mechanical ventilation (0.011), outcome (0.033), hematotoxicity (0.021), neurotoxicity (0.042) and other toxicity (0.038) exhibit significant interactions with sex. A significant interaction exists between first aid and neurotoxicity (0.010), hematotoxicity (0.023), other toxicity (0.014), blood products (0.019), mechanical ventilation (0.031) and outcome (0.045). Hematotoxicity (0.001), other toxicity (0.006), blood products (0.002), mechanical ventilation (0.005) and outcome (0.014) exhibit significant interactions with neurotoxicity. Hematotoxicity exhibits a significant interaction with other toxicity (0.003), blood products (0.007), mechanical ventilation (0.016) and outcome (0.013). Other toxicity exhibits substantial interactions with blood products (0.012), mechanical ventilation (0.019) and outcome (0.029). Mechanical ventilation (0.009) and outcome (0.015) are significantly influenced by blood products. Mechanical ventilation exhibits a substantial interaction with the outcome (0.022). The statistical significance of each interaction is denoted by the p-values, which aid in the identification of the clinical variables that are most closely associated with patient outcomes in snakebite cases.

The following table illustrates the risk and odds ratios for adverse outcomes (including mortality and severe complications) that are linked to various types of toxicity in snakebite patients. The risk ratio and odds ratio of neurotoxicity are 2.56 and 3.12, respectively, with a p-value of 0.001, respectively, suggesting a strong and statistically significant correlation with adverse outcomes. Hematotoxicity exhibits a risk ratio of 1.78 and an odds ratio of 2.05, with a p-value of 0.023, which also suggests a significant association, albeit one that is weaker than neurotoxicity. The most significant and robust association with adverse

outcomes is demonstrated by the highest risk ratio of 3.47 and an odds ratio of 4.10, with a p-value of 0.000, for other toxicity. These figures indicate that patients who have these toxicities are at a significantly increased risk of experiencing severe negative health outcomes as a result of a snakebite.

RESULTS AND DISCUSSIONS

The investigation found that an increased quantity of ASV vials, along with the occurrence of neurotoxicity and other toxicities, had a significant impact on the likelihood of mortality in individuals bitten by snakes. In addition, arriving at the hospital early and being younger were linked to improved outcomes. The findings emphasise the crucial significance of prompt intervention and focused treatment in enhancing the prognosis of snakebite patients.

The thorough analysis of correlations uncovered significant relationships among the clinical variables that were studied. There is a clear connection between the amount of anti-snake venom (ASV) given and how long a patient stays in the hospital. This means that patients with more severe cases who need higher doses of antivenom also tend to have longer hospital stays[11]. Previous research has shown that the seriousness of envenoming, as indicated by the requirement for additional antivenom, plays a crucial role in determining clinical outcomes[12].

There appears to be a small connection between age and the number of ASV vials used, as well as the length of hospital stay. This suggests that younger patients might have faster recoveries and possibly need less antivenom[13]. Research has shown that age plays a role in the severity of snakebite cases, with children and the elderly being more susceptible to complications[14,15]. These age groups are more vulnerable due to various factors, including variations in how venom is processed in the body, the presence of other medical conditions, and the body's ability to recover[16].

The moderate positive correlations between neurotoxicity, hematotoxicity and other toxicities with the need for mechanical ventilation and blood products emphasise the importance of these complications in treatment and the potential for negative outcomes. Respiratory paralysis can be caused by neurotoxicity, which may require mechanical ventilation to help with essential bodily functions[19]. In the same way, when hematotoxicity occurs, it can lead to coagulopathy and bleeding. This may require the use of blood products[20]. These toxicities are important signs of how serious the envenoming is and the risk of life-threatening complications.

The logistic regression analysis revealed several important factors that can predict whether snakebite patients will survive or be discharged. The study found that administering a larger number of ASV vials was linked to a higher likelihood of experiencing a negative outcome. This highlights the significance of promptly and efficiently providing antivenom treatment[21]. Neurotoxicity and other toxicities were found to be significant risk factors, which supports the findings from the correlation analysis[22,23]. These findings highlight the importance of quickly identifying and addressing these complications in order to enhance patient outcomes.

The analysis of how clinical variables and patient outcomes interacted provided additional evidence of the important role played by neurotoxicity and hematotoxicity. These toxicities demonstrated strong correlations with negative outcomes, underscoring their importance in predicting prognosis[24,25]. There is a possibility that the first aid measures could have an impact, although the evidence is not strong enough to draw definitive conclusions. This indicates the importance of conducting more research to understand how effective and standardised prehospital care should be for individuals bitten by snakes[26].

The risk and odds ratios clearly highlight the significant increase in the likelihood of negative outcomes linked to neurotoxicity, hematotoxicity and other toxicities[27,28]. Individuals experiencing these complications faced considerably greater risks and chances of unfavourable outcomes in comparison to those who did not encounter these toxicities. The significance of promptly identifying and effectively treating these severe complications cannot be overstated, as it greatly enhances the chances of a positive outcome for individuals affected by snakebite envenoming[29].

On the other hand, a research conducted in Bangkok examined the effects of green pit viper bites on people of different age groups. The study discovered that there were no significant differences in the rates of blood clotting disorders, administration of antivenom and hospital admissions between older and younger adults[30]. It appears that the severity of envenomation for certain snake species may not be greatly influenced by age.

A recent research conducted on snakebite patients in India revealed that the mortality rate was 2.1% among individuals who received antivenom treatment. Encouragingly, a significant majority (84%) of patients fully recovered with the help of this treatment[31]. It is crucial to promptly and effectively administer antivenom in order to improve outcomes.

Nevertheless, a research conducted in Australia regarding snakebite-associated thrombotic

microangiopathy (TMA) revealed that even with the administration of antivenom, TMA still affected a considerable number of patients and there was no indication of any advantages from therapeutic plasma-exchange[17,18]. It appears that managing the complications of snakebite envenoming may require additional interventions, in addition to antivenom[32].

In addition, a study conducted in Martinique examined the infectious complications that can arise from snakebites caused by Bothrops lanceolatus. The study discovered that the severity of envenoming was strongly linked to the occurrence of infection[33]. It is crucial to promptly identify and treat severe envenomations in order to avoid additional complications.

The study's findings offer valuable insights into the clinical factors that affect the outcomes of snakebite envenoming. The mortality rate was found to be significantly influenced by factors such as the number of ASV vials administered, the occurrence of neurotoxicity, hematotoxicity and other toxicities. This emphasises the importance of promptly and effectively addressing these complications. The heightened dangers and likelihood of negative consequences linked to these toxicities highlight the crucial importance of these clinical characteristics in the outlook for individuals bitten by snakes. These findings can help healthcare providers develop specific management protocols and make informed decisions about the risk stratification and optimisation of care for patients who have been bitten by snakes.

CONCLUSION

The results of this study indicate that timely and appropriate administration of ASV, along with close monitoring of neurotoxicity and hematotoxicity, could play a vital role in enhancing the outcomes for individuals affected by snakebites. Recovery rates could be improved by providing first aid at a younger age. These findings emphasise the possible advantages of quick, standardised treatments that are customised based on the seriousness of the snakebite. Further research can be conducted to enhance ASV protocols and first aid measures, aiming to enhance the management of snakebite cases. In addition, implementing better record-keeping systems in areas with limited resources could help us gain a more precise understanding of the frequency and outcomes of snakebites.

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