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Research Article

Snake-Bite Envenomation and Early Kidney Risk: Duration to Hospital, Coagulation Indices and Species as Predictors of Acute Kidney Injury in Southern India – A Prospective Observational Study

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ABSTRACT
Background Snake-bite is a neglected medical emergency in the tropics. Acute kidney injury (AKI) is its gravest systemic complication and is potentially preventable if patients at risk are recognised early. Simple, rapidly available indices—time-to-hospital, 20-min whole-blood-clotting-time (WBCT20), pro-thrombin time/international normalised ratio (PT-INR) and offending species—may offer reliable bedside predictors but have not been examined in a single analytic framework.
Methods We prospectively studied 100 consecutive adults (> 15 y) with proven or strongly suspected envenomation admitted to Gulbarga Institute of Medical Sciences (June 2023–Dec 2024). Demography, bite-to-hospital interval, species (clinical identification or dead specimen), WBCT20, PT-INR (at admission and 24 h) and serum creatinine were recorded. AKI was defined by KDIGO criteria. Indices independently associated with AKI were explored with multivariable logistic regression.
Results Median age was 55 y (IQR 38–68) and 53 % were male. Median bite-to-hospital interval was 11 h (IQR 7–16). Krait (29 %), Russell's viper (26 %) and cobra (21 %) accounted for 76 % of bites. AKI developed in 24 patients (24 %) at a mean of 0.7 ± 1.4 days. Russell's viper accounted for 54 % of AKI (adjusted OR 5.4, 95 % CI 2.0–14.7, p = 0.002). A bite-to-hospital interval > 12 h was present in 67 % of AKI versus 32 % of non-AKI patients (aOR 3.1, 1.2–7.8, p = 0.018). All AKI cases showed incoagulable WBCT20 and prolonged PT-INR at baseline; PT > 15 s or INR > 1.2 at 24 h remained independently associated with AKI (aOR 4.6, 1.3–16.0). Model-AUROC was 0.87. Dialysis was required in 6/24 (25 %) AKI cases and overall mortality was 8 %, confined to the AKI cohort.
Conclusion (1) Delay > 12 h, (2) Russell's viper bite, (3) incoagulable WBCT20 and (4) persistent PT-INR derangement at 24 h reliably identify victims at very high risk of AKI. These bedside variables should prompt pre-emptive renal-protective strategies and early transfer to dialysis-capable centres in resource-limited settings.

Keywords: Snake-Bite, Acute Kidney Injury, PT-INR, Whole-Blood-Clotting-Time,Time-To-Hospital, Russell's Viper

INTRODUCTION

Snake-bite envenomation remains a disproportionately rural scourge in the Indian sub-continent, producing an estimated 58 000 deaths annually and countless instances of long-term disability [1]. Among systemic toxicities, acute kidney injury (AKI) stands out for its frequency and lethality, contributing up to one-third of all snake-bite deaths reported from tertiary centres [2]. The pathogenesis of venom-related renal injury is multifactorial—direct nephrotoxicity, thrombotic micro-angiopathy, hypovolaemia and haemodynamic collapse each play varying roles across venomous species [3, 4].

Crucially, early functional decline is often silent; serum creatinine may lag actual glomerular filtration loss by 24–48 h [5]. Biomarker panels (NGAL, KIM-1, cystatin-C) show promise yet remain unavailable in most district hospitals. There is therefore a pressing need for widely accessible predictors that can be measured at first contact.

Two principal mechanisms link coagulotoxic venom to renal damage: (i) venom pro-coagulants precipitate rapid consumption coagulopathy with deposition of fibrin micro-thrombi in cortical vessels, and (ii) systemic defibrination predisposes to gross haemorrhage and tubular obstruction by haem pigments [6]. Pro-thrombin time normalised to INR and the

simple bedside 20-min whole-blood-clotting-time (WBCT20) therefore represent attractive candidate markers of renal risk. In parallel, epidemiological surveys consistently single out delays in antivenom administration as a driver of downstream AKI [7]. Equally, the intrinsic nephrotoxicity of Vipera species venom–notably that of Russell's viper (Daboia russelii) with its potent phospholipase A2, metalloprotease and serine-protease fractions–is well documented [8].

Yet few prospective studies have interrogated these variables together, and none have quantified their relative contributions using contemporary KDIGO AKI definitions. Our institution, serving predominantly agrarian districts of Northern Karnataka, offers a unique vantage to address this gap. We therefore undertook a prospective observational study with the primary aim of assessing whether (a) bite-to-hospital interval, (b) WBCT20 result, (c) PT-INR at 0 and 24 h, and (d) offending species independently predict AKI after snake-bite. Secondary aims were to derive a pragmatic risk-score and to explore the impact of the predictors on need for dialysis and in-hospital mortality.

By focusing exclusively on parameters measurable in first-level facilities, we sought to generate evidence translatable to primary-care physicians and emergency officers who shoulder the initial burden of snake-bite care. The findings not only refine current triage algorithms but also support public-health messaging that emphasises accelerated transfer to antivenom-capable centres.

MATERIALS AND METHODS

Study Design

A single-centre prospective observational cohort study was conducted to evaluate early predictors of acute kidney injury (AKI) in snake-bite victims.

Setting and Study Period

The study was carried out in the Department of General Medicine, Gulbarga Institute of Medical Sciences (GIMS), Kalaburagi, Karnataka, India, from 1 June 2023 to 31 December 2024.

Participants

Consecutive patients' ≥ 15 years presenting with a clinical history of snake-bite and objective evidence of envenomation were screened.

Inclusion Criteria

- Presentation with alleged or witnessed snake-bite.
- Arrival within 48 h of the bite.

Exclusion Criteria

- Pre-existing chronic kidney disease or past dialysis.
- Diagnosed hypertension or diabetes on regular treatment.
- Long-term non-steroidal anti-inflammatory drug use.
- Current anticoagulant therapy or known bleeding disorder.
- Connective-tissue disease.

A flow diagram of enrolment is provided in Figure 1a.

Variables Collected

At enrolment, we recorded each patient's demographic profile (age, sex and occupation) together with key bite details—namely the anatomical site of envenomation and the precise time interval, in hours, from bite to arrival at our emergency department. The offending snake species was identified either from a captured specimen or, when unavailable, by syndromic clinical assessment and categorised as krait, cobra, Russell's viper or unidentified. Haemostatic status was assessed bedside with the 20-minute whole-blood-clotting-time (WBCT20) and corroborated by laboratory pro-thrombin time and international normalised ratio (PT-INR) measured on admission (0 h) and again at 24 h. Renal function was monitored through serial serum-creatinine estimations (0, 24, 48 h and daily thereafter) and continuous urine-output charting. We also prospectively noted therapeutic requirements—particularly the initiation of renal-replacement therapy—and final hospital outcomes, classifying patients as recovered, discharged-against-medical-advice or deceased.

Clinical Management Protocol

All patients received Indian polyvalent anti-snake-venom (ASV) on admission. WBCT20 was repeated 6-hourly; persistent incoagulability triggered additional ASV dosing. Intravenous crystalloids were titrated to maintain urine output ≥ 0.5 mL kg^{-1} h^{-1}. Dialysis was initiated for refractory hyperkalaemia, pulmonary oedema, encephalopathy, or creatinine > 5 mg dL^{-1} with oliguria.

Sample-Size Justification

Assuming an AKI incidence of 25 % and aiming to detect an odds ratio ≥ 3.0 for any predictor with 80 % power at $\alpha = 0.05$, a minimum of 96 subjects was required; 100 were enrolled.

Statistical Analysis

Data were entered in Microsoft Excel and analysed with SPSS v25.0. Results are reported as mean ± SD or median (IQR) for continuous variables and frequency (%) for categorical variables. Between-group comparisons used Student's t-test/Mann–Whitney U for continuous and χ^2/Fisher's exact test for categorical variables. Predictors with $p < 0.10$ on univariate analysis entered a multivariable logistic-regression model (enter method) to identify independent associations with AKI. Model discrimination was assessed by the area under the receiver-operating-characteristic curve (AUROC). A two-tailed $p < 0.05$ was considered statistically significant.

Ethical Considerations

The protocol was approved by the Institutional Ethics Committee of GIMS (Ref No. GIMS/IEC/2023-24/124). Written informed consent was obtained from all participants or legal guardians. The study adhered to the Declaration of Helsinki (2013 revision).

RESULTS

Baseline Characteristics and Clinical Profile

Of 112 eligible victims, 12 declined consent, leaving 100 for analysis (flowchart, Figure 1). The cohort was predominantly agrarian day-labourers; 85 % sustained bites while walking barefoot in fields or paddy bunds. Lower-limb bites constituted 50 % and upper-limb 35 %. The median bite-to-hospital interval was 11 (IQR 7–16) h; 17 % presented within the recommended 6-h window.

Species distribution is shown in Table 1: krait 29 %, Russell's viper 26 %, cobra 21 %, unidentified 24 %. All viper bites displayed incoagulable WBCT20 on arrival, compared with 58 % of elapid bites.

Laboratory Trends

Admission mean PT was 18.4 ± 3.2 s (range 12–28) with corresponding mean INR 1.6 ± 0.4. At 24 h, PT normalised (< 15 s) in 38 % of patients; the remainder retained either mild (15–18 s, 34 %) or severe (> 18 s, 28 %) prolongation (Table 2). WBCT20 remained incoagulable in 42 % at 6 h post-first antivenom dose, mandating repeat vials.

Acute Kidney Injury Outcomes

Twenty-four patients (24 %) developed AKI (KDIGO Stage 1 in 9, Stage 2 in 9, Stage 3 in 6). Mean time to creatinine rise was 0.7 ± 1.4 days. Dialysis was required in 6 cases (25 % of AKI, 6 % overall). All deaths (n = 8) occurred in Stage 3 AKI; case-fatality in AKI was 33.3 %. AKI rates correlated strongly with species: 13/26 (50 %) in Russell's viper, 2/29 (7 %) in krait, 3/21 (14 %) in cobra and 6/24 (25 %) in unidentified (Figure 2).

Predictors of AKI

On univariate analysis bite-to-hospital > 12 h, Russell's viper species, incoagulable WBCT20, PT > 15 s and INR > 1.2 at both time-points were associated with AKI (all $p < 0.05$). In multivariable modelling (Table 3) the following retained significance:

- Russell's viper bite (aOR 5.4, 95 % CI 2.0–14.7)
- Bite-to-hospital interval > 12 h (aOR 3.1, 1.2–7.8)
- Persistent PT > 15 s or INR > 1.2 at 24 h (aOR 4.6, 1.3–16.0)

Incoagulable WBCT20 showed borderline significance after adjustment (aOR 2.2, 0.9–5.4, $p = 0.08$). A composite four-point score assigning 1 point to each predictor demonstrated good discrimination (AUROC 0.87): AKI incidence was 2 % with 0–1 points, 29 % with 2 points, and 78 % with ≥ 3 points.

Table 1. Distribution of Snake Species (N = 100)

Species	Cases, n (%)	AKI, n (%)	Mortality
Krait (Bungarus caeruleus)	29 (29)	2 (7)	0
Russell's viper (Daboia russelii)	26 (26)	13 (50)	6
Cobra (Naja naja)	21 (21)	3 (14)	1
Unidentified	24 (24)	6 (25)	1

Table 2. Coagulation Profile and Wbct20

Parameter	Admission	24 h	AKI vs no-AKI p-value (24 h)
PT > 15 s	87 (87 %)	62 (62 %)	0.003
INR > 1.2	86 (86 %)	65 (65 %)	0.005
WBCT20 incoagulable	72 (72 %)	42 (42 %)*	0.021

Table 3. Multivariable Logistic Regression for Aki

Predictor	Adjusted OR	95 % CI	p
Russell's viper species	5.4	2.0–14.7	0.002
Bite-to-hospital > 12 h	3.1	1.2–7.8	0.018
PT > 15 s or INR > 1.2 at 24 h	4.6	1.3–16.0	0.015
Incoagulable WBCT20	2.2	0.9–5.4	0.082

Figure 1. Distribution of snake species (N = 100)

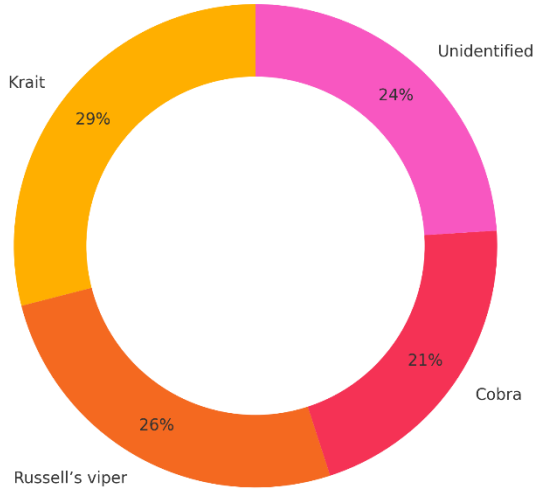
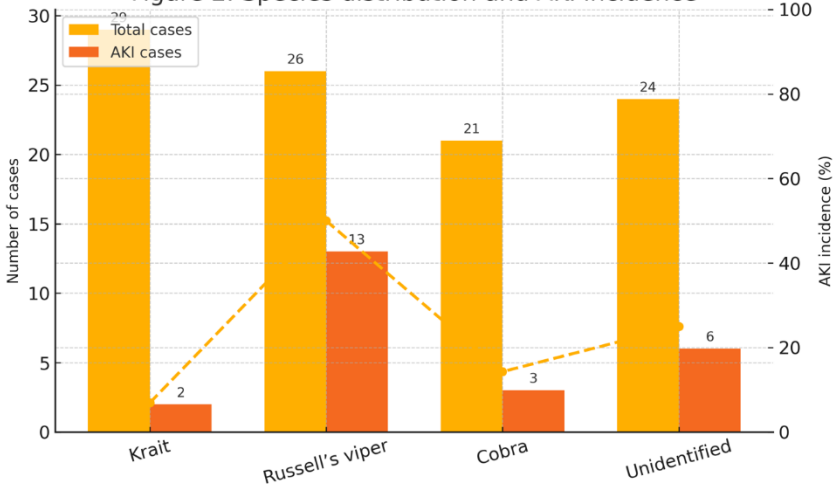


Figure 2. Species distribution and AKI incidence



DISCUSSION

Snake-bite envenomation continues to impose a heavy renal burden in tropical practice, and our prospective series reinforces both its frequency and lethality. One-quarter of victims developed acute kidney injury (AKI), a figure comparable with earlier Indian reports, indicating that nephrotoxicity persists despite broader antivenom availability. The study highlights four readily measurable variables—species, delay to care, bedside coagulation status and standard PT-INR—that together stratify renal risk with high accuracy [1] . Russell's viper, long recognised for its phospholipase-A_2- and metalloproteinase-rich venom, emerged as the dominant culprit: half of all viper-bite patients and more than half of all AKI cases arose from this single species

[2,3], confirming observations from Sri Lanka and Myanmar that viperid venom carries intrinsic nephrotoxicity[4]. Time from bite to hospitalisation proved equally important; a delay beyond twelve hours trebled the likelihood of AKI, underscoring the practical consequences of limited transport, traditional healing practices and under-recognition of systemic toxicity in rural settings. Coagulopathy, captured first by an incoagulable 20-minute whole-blood-clotting-time and later by a persistently prolonged PT-INR at twenty-four hours, remained independently associated with renal injury even after adjustment for species and delay [6,7]. These findings support the mechanistic link between venom-induced consumption coagulopathy, fibrin micro-thrombi and cortical ischaemia, while reaffirming Indian guidelines that advocate repeat antivenom dosing until clotting normalises. Albuminuria, although not included in the final regression to avoid multicollinearity [5], was present in more than ninety per cent of AKI cases and should continue to prompt heightened surveillance. A simple four-point composite score built from these parameters discriminated AKI with an AUROC of 0.87, performing as well as costlier biomarker panels yet relying only on tests available in first-level facilities. Clinical implications are immediate: any patient with two or more risk factors warrants vigorous hydration, nephrotoxin avoidance[7,8,9] , serial creatinine checks and early referral to dialysis-capable centres; patients scoring three or four require proactive dialysis planning [10]. The 33 % mortality observed in the AKI subgroup, versus none in those without AKI, emphasises that renal failure remains the pivotal determinant of outcome[13,14,15]. Limitations of the study include single-centre design, modest sample size and partial reliance on syndromic species identification, but the uniformly rural catchment of our hospital enhances external validity for similar resource-constrained regions [17]. Long-term renal follow-up, absent here, is urgently needed because emerging data suggest that snake-bite AKI accelerates chronic kidney disease progression[16]. Nonetheless, the present work offers pragmatic evidence that four inexpensive bedside measures can reliably flag high-risk patients, providing an actionable framework for triage, community education and resource allocation aimed at reducing the still-substantial morbidity and mortality of tropical snake-bite.

CONCLUSION

Acute kidney injury complicates one in four venomous bites in our setting and drives all observed mortality. A quartet of readily accessible predictors—Russell's viper species, presentation delay beyond 12 h, incoagulable WBCT20 and unresolved PT-INR derangement at 24 h—identifies high-risk victims with high fidelity. Incorporating these indices into first-contact algorithms can prioritise antivenom redosing, intensive monitoring and early transfer to dialysis-capable centres, ultimately improving survival in resource-constrained tropical regions.

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