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Overview of the Venomous Snakes in West Africa, Clinical Manifestation, Diagnosis and Treatment

Ameh MP[1], Mamman M[1], Yusuf PO[1], Magaji MG[2], Ada G[1], Akefe IO[3*] and Ugwoke PE[4]

[1]Department of Veterinary Pharmacology and Toxicology, Ahmadu Bello University, Zaria

[2]Department of Pharmacology and Therapeutics, Ahmadu Bello University, Zaria

[3]Department of Veterinary Physiology, Biochemistry and Pharmacology, University of Jos, Zaria

[4]Department of Medicine, Ahmadu Bello University Teaching Hospital, Zaria

[*]**Corresponding author:** Akefe IO, Department of Veterinary Physiology, Biochemistry and Pharmacology, University of Jos, Zaria, Tel: +2348034986335; E-mail: akefeisaac@yahoo.com

Abstract

Snakebite remains a major medical problem among rural community of the savannah region of West Africa including Nigeria, as it is a leading cause of mortality and morbidity among farmers, pastoralists, hunters, children in these areas. Medically important West African snakes belong to the following families; Viperidae, Elapidae, Atractaspidae and Colubridae, of which three species from the first two families; carpet viper (*Echis ocellatus*), puff adder (Bitis arietans) and black-necked spitting cobra (*Naja nigricollis*) being the most common culprit of envenomation in Nigeria. Snake venoms are classified based on their mode of action when in systemic circulation, which are; haemotoxic, neurotoxic and cytotoxic (necrotoxic or cardiotoxic), which may in turn as the case may be distort clotting cascade or cause nervous derangement in victims. Several factors contribute to the severity and outcome of snakebite, namely; size of victim, comorbidity, part bitten, individual sensitivity, bite characteristics, species of snake, secondary infections and management. Some diagnostic methods for snake envenomation are; 20-minutes whole blood clotting test, ELISA and lateral flow immunochromatographic assay. Proper identification of snake and /or diagnosis will help in alleviating the severity of snakebite cases.

Keywords: ***Snakebite; Venom; ELISA; Cytotoxic***

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Introduction

Snakebite is a major medical problem among rural communities of the savanna region of West Africa, notably in Benin, Burkina-Faso, Cameroon, Ghana, Nigeria and Togo [1]. Despite urbanization and destruction of their habitat, venomous snakes remain plentiful in most parts of Africa. Throughout the continent, snakes are feared and misunderstood even though

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most are harmless. Venomous snakes bite humans only when they feel threatened, are trodden on or picked up inadvertently. Snakes are creatures that inspire awe, reverence and even worship in some areas, and they are exhibited as performing animals by traditional snake charmers. Despite this, they are usually loathed and killed on sight. Their survival depends on their remaining undetected. Snakes co-exist with humans in homes, gardens and outhouses but their presence usually goes unnoticed.

Fear of snakes is understandable since they are responsible for an untold number of bites and numerous deaths as well as cases of permanent physical handicap. No country is free from the risk of snakebite, and in some rural areas, such as the Benue Valley of northern Nigeria, snakebite is a leading cause of morbidity and mortality among farmers, pastoralists, hunters and children. Snakes such as puff adders (*Bitis arietans*) also kill and injure many domestic dogs and grazing animals. The exact burden of human suffering attributable to snakebite is difficult to determine because bites occur most commonly in rural areas where the first impulse of many bite victims is to seek the help of a trusted traditional healer rather than go to a Western-style hospital where their attendance may be recorded and reported to a national authority [2].

Families of medically important West African snakes

There are four families of medically important snakes in West Africa namely;

a) Viperidae eg. *Echis ocellatus*, *E. carinatus*, *E. leucogaster*, *Bitis arietans* etc.
b) Elapidae eg. *Naja nigricollis*, *N. katiensis*, *N. haje*, *Dendroaspis viridis*, *D. jamesoni* etc.
c) Atractaspidae eg. *Atractaspis microlepidota*
d) Colubridae eg. *Dispholidus typus* and *Thelotornis kirtlandii*

These four families have been identified to be responsible for envenomation in Nigeria with three species from the first two families - Carpet viper (*Echis ocellatus*), black-necked spitting cobra (*Naja nigricollis*) and puff adder (*Bitis arietans*) being the most common culprits for envenomation in Nigeria [3].

Viperidae

Vipers or adders are relatively thick bodied, sluggish, mainly terrestrial snakes which have long, curved, cannulated and fully erectile solenoglyphous fangs which fold down against the upper jaw in a mucous membrane sheath when the snake is not striking.

Figure 1: West African or ocellated carpet viper *Echis ocellatus* Kaltungo, Nigeria.

Echis ocellatus

The saw-scaled or carpet viper (*Echis ocellatus*) has proved to be the most important cause of snakebite mortality and morbidity in West Africa. It is a small, nocturnal, ground-dwelling snake with a pear-shaped head, and somewhat triangular flank (Figure 1). It has an average length of 53.4 cm, 6.1 cm in diameter, with an average tail length of 6.1 cm and gives an average venom yield of 0.325 ml per snake per day [4].

The main clinical features of *E. ocellatus* envenoming are systemic hemorrhage, incoagulable blood, shock, local swelling, bleeding and occasionally necrosis [5]. All body systems may be affected; cardiac and hemodynamic abnormalities may result while the strongest predictor of mortality is central-nervous-system involvement with intracranial hemorrhage [6-8]. *Echis ocellatus* envenomation may manifest features such as spontaneous bleeding from the gums, haematuria, haematemesis, melena, haematochezia, haemoptosis, dry gangrene, angioedema, bullae and coagulopathy [9].

Bitis arietans

Snakes in the genus *Bitis* are characterized by a wide head and narrow neck. The tail appears oddly short in females and only less so in males. The four larger species have a total length of 80 cm to 2 m. The puff adder is the most widespread and unmistakable; body stout and massive; brown or grayish with well-marked chevron markings; ground-dwelling with somewhat triangular head. It has large hinge-like fangs and is found throughout the savannah regions as well as the rainforest belt of Nigeria. Medically, it is one of the most important snakes in Africa. It has an average length of 110.6 cm, diameter of 21.4 cm with an average tail length of 7.7 cm, and gives an average venom yield of 4.9 ml per snake per day [4]. Its venom is strongly hemotoxic, destroying blood cells and causing extensive tissue damage with dry gangrene [9]. *B. arietans* is a species of viper which occupies densely populated habitats throughout the Middle East and savannah areas of Sub-Saharan Africa [10]. The precise number of human fatalities due to *B. arietans* envenoming is unknown. However, bites by this species are widely believed to contribute to a substantial proportion of the estimated 43,000 deaths from snake bite reported in Africa annually [11]. This makes B. arietans a significant public health concern in this region. The local effects of *B. arietans* envenoming include swelling, blistering, arterial thrombosis, bruising and necrosis [12]. The systemic effects of human envenoming include hypotension, bradycardia, spontaneous bleeding and thrombocytopenia [12]. Although death due to envenoming is rare, the absence of prompt treatment by antivenom can lead to poor quality of life as a result of disabilities due to local necrosis [13].

Figure 2: Puff adder Bitis arietans Abuja, Nigeria.

Elapidae

The majority of elapids are long and slender. The rinkhals and the cobras are easily identified, since they usually rear their heads and spread a hood. Some have the ability to spit venom. There is a relatively high incidence of serious spitting cobra bites in Africa. The black mamba may also spread a narrow hood when threatened. Compared to vipers, elapids possess relatively short (up to about 10 mm long), fixed front (proteroglyphous) fangs. In the case of mambas, the fangs are mounted at the very front of the maxilla, and can rotate at their articulation with the pre-frontal bone. Their venoms are potently neurotoxic and cytotoxic and are common cause of fatal snakebite [14].

***Naja nigricollis* (Black-necked spitting cobra)**

Found mainly in moist or dry savanna or sahel, where they shelter in abandoned termite mounds, rodent burrows, or hollow trees. Widespread across many countries in central and southern Africa, generally nocturnal (or crepuscular), juveniles often active during day. Prey on a wide variety of animals, including toads, chickens (often raid chicken runs), other birds and/or eggs, small mammals, and lizards. It has an average length of 123 cm, diameter of 8.8 cm, tail length of 8 cm, and give an average venom yield of 2 ml per snake per day [4]. Venom primarily cytotoxic, causing serious local tissue damage and wet gangrene though also contains Short-chain alpha-neurotoxin that causes Post-synaptic non-depolarizing block leading to paralysis of their victims [15]. Large specimens can "spit" venom as far as 3 m, usually aiming at intruders' eyes (or heads). Venom does not affect unbroken skin, but can cause great pain and possible tissue destruction in the eyes.

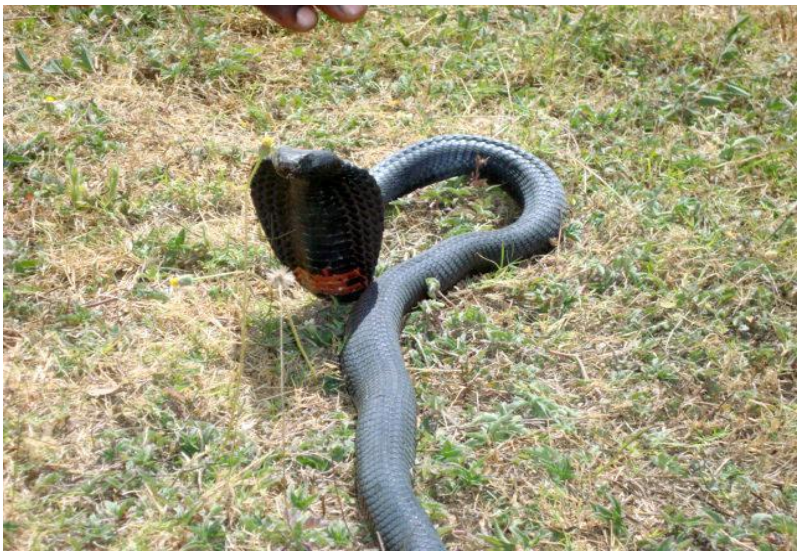

Figure 3: Adult Naja nigricollis from Zaria Kaduna State.

Naja katiensis

One of the most common causes for snake-bite mortality in Senegal. Found mainly in savannah and semi-desert. Mainly terrestrial but will climb into low bushes; mainly crepuscular, but sometimes basks in sun. Fast-moving and alert. Usually tries to get away if disturbed, but if cornered or molested, it will rear up the front part of its body and spread a narrow hood. If further disturbed, it often "spits" (sprays) twin jets of venom at the intruder's head and eyes. It has an average length of 71.7 cm, diameter of 7.2 cm, tail length of 6.9 cm and average venom yield of 1.2 ml per snake per day [4].

Figure 4: *Naja katiensis* in Bakori Katsina State.

***Dendroaspis spp* (Mambas)**

Large, agile, slender diurnal elapid snakes with a long flat-sided head, a medium-sized eye and a round pupil. Scales are smooth and narrow. All except the black mamba (*Dendroaspis polylepis*) are arboreal. Coloration varies from light green to olive brown and dark grey. 1.5 m to 3.5 m in size. Coffin shaped head. The black mamba may spread a narrow hood. They are highly dangerous snakes owing to their neurotoxic venom. Species in this genus are; *D. jamesoni*, *D. polylepis*, *D. angusticeps* and *D. viridis*.

Figure 5: Eastern green mamba *Dendroaspis angusticeps*.

Figure 6: Traill's mamba *Dendroaspis jamesoni kaimosi* Kakamega, Kenya.

Atractaspidae

The burrowing asps are fossorial, living mostly underground in deserted termite mounds, under stones or logs, or in soft soil or sand. They are mostly grey, black or brown and most are relatively small (30 cm - 70 cm in length). Nocturnal and usually emerge on warm, wet summer evenings, especially after heavy rains. When the snake bites (strikes) the fangs are exposed out of the sides of the mouth and are then hooked or jabbed into the victim with a backward jerk of the head. They are extremely irritable, striking in sideways swings and sweeps, and showing annoyance by flattening the body. Accidental bites usually occur at night when the victim treads on the snake.

Atractaspis microlepidota

Uniformly black or dark brown with a small, narrow head. Average 55 cm, maximum 75 cm. The venom glands are extremely elongated, extending under the skin for about 15% of the body length behind the head. It has a rather inoffensive disposition; however, it will quickly turn and bite if restrained or touched. Its venom is a potent hemotoxin for such a small snake. Its fangs are exceptionally long. A bite can result even when picking it up behind the head. It is best to leave this snake alone. Small-scaled burrowing asp (*Atractaspis microlepidota*) causes pain, swelling, nausea, vomiting and ocalize and in some cases fever and haematuria.

Figure 7: Small-scaled burrowing asp *Atractaspis microplepidota* fallax Watamu, Kenya.

Colubridae

The back-fanged snakes have fixed, grooved rear fangs that are situated quite far back in the mouth. Although only the boomslang and the vine snakes have caused fatal bites, all back-fanged colubrids should be regarded as potentially dangerous to man and must be handled with caution.

Dispholidus typus

Very active and largely arboreal; feeds mainly on chamaeleons and other tree lizards, nestling birds and eggs; the only dangerous back-fanged (opisthoglyphodont) snake, but fortunately reluctant to bite. Venom contains enzymes which activate prothrombin and factor X, leading to a consumptive coagulopathy, severe hypofibrinogenaemia and fatal bleeding if untreated (WHO, 2010).

Figure 8: Boomslang *Dispholidus typus*.

Thelotornis kirtlandii

Thelotornis kirtlandii is an arboreal, venomous colubrid snake with a wide distribution ranging from the islands of the Bijagos Archipelago, Guinea Bissau; east through forested areas of West Africa and the Congo ba-sin to Uganda and southern Sudan; south to northern Angola, north-western Zambia and south-central Tanzania [16]. It is typically a forest species [16], and in southern Nigeria may attain high population densities in mangrove habi-tats [17]. Although the diet of its savanna congener, *Thelotornis capensis*, is well known [18], few data are available on the food habits of *T. kirtlandii*, possibly due to its elusive habits and relatively inaccessible rainforest and mangrove habitats. From a swamp-rainforest of south-eastern Nigeria [19], recorded eight food items: one small bird (*Cisticola galactotes*) and seven geckos (*Hemidactylus fasciatus*). Here we present a detailed account of the diet of free-ranging *T. kirtlandii* from a region situated within the continuous Guinea-Congo rainforest belt (i.e. southern Nigeria, West Africa), with an analysis of prey-size predator-size relationships.

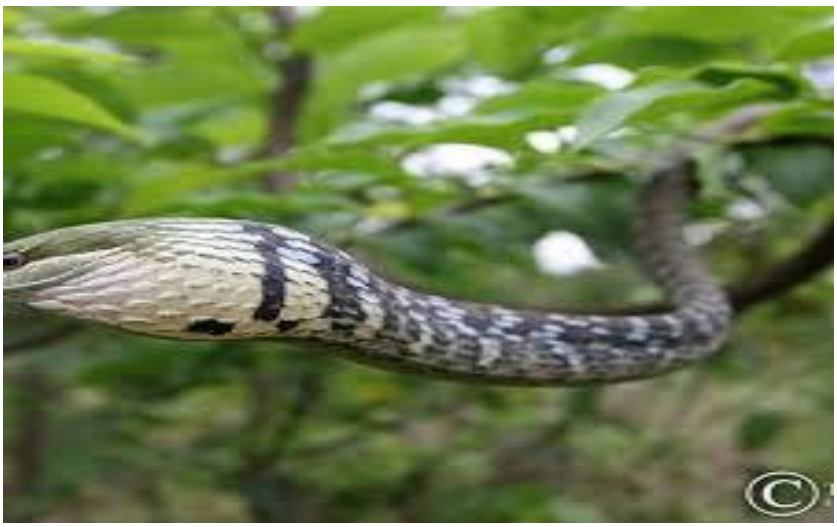

Figure 9: *Thelotornis kirtlandii*.

Classification of snake venom

Usually snake venoms are classified based on their mode of action. The different types so far documented are characterized as haemotoxic, neurotoxic, cytotoxic (necrotoxic or cardiotoxic) [20].

Haemotoxic effect

Snake venom exerts different effects on different body tissues. The haemotoxic venom causes breakdown of blood cells and inflammation, and is usually the most painful. This effect can be manifested in three ways:

Haemolytic effect

This is believed to occur as a result of the presence of an enzyme known as haemolysin in viperid venoms. This enzyme continually lyses erythrocytes which are broken down rapidly resulting in anaemia, haemoglobinuria, pherocytosis, angioedema, blisters and in some cases icterus. Blood picture show spherocytosis, decrease in phagocyte population, lymphocytopenia, anisocytosis, poikilocytosis, polychromacia and leukocytopenia [21].

Haemorrhagic effect

This is the ability of venom to lyse intact blood vessels, especially capillaries through the activities of the enzymes, haemorrhagins and phospholipases (especially phospholipase A2) [22-24]. This is clinically manifested as gum bleeding, haematuria, haemachezia, malaena, haemoptosis and spontaneous bleeding from the skin [21,25,26].

Coagulant effect

This is the failure of blood to clot as a result of inhibition of clotting factors II and X, thus, resulting in excessive blood loss from wounds, fang marks, or bruises. This coagulant effect has been used to develop the 20 Minutes Whole Blood Clotting Test (20WBCT), which is used clinically to diagnose carpet viper envenomation in endemic areas [20,21].

Neurotoxic effect

The main toxins from snake venom that affect the central nervous system are neurotoxins and dendrotoxins. The general observation from neurotoxin envenomation is the development of cranial nerve palsies, which are characterized by ptosis, blurred vision, difficulty in swallowing, slurred speech and weakness in facial muscle. Similarly, dendrotoxins have been demonstrated to block particular subtypes of voltage-dependent potassium channels in neurons [24].

Cytotoxic effect

Snake venom cytotoxins are highly basic amphipathic proteins and they constitute as much as 40-70% of cobra venom (*Naja and Haemachatus*). The mechanisms for cytotoxin-mediated toxicity include modulating the activity of membrane-bound enzymes, depolarizing excitable membranes of heart cells and of neurons, inhibiting platelet aggregation, inducing hemolysis and cytotoxicity, and bringing about cardiac arrest [27]. It is widely accepted that most pathological activities of cytotoxins are based on their ability to bind to cell membranes leading to alterations in the organization and function of lipid bilayers [28-30]. Snake envenomation due to *Naja* species is highly prevalent in Africa and mortality is often associated with the potent necrotic activity of *Naja*-derived cytotoxins. Pathologically, cytotoxins are responsible for severe myotoxicity, hemolysis, and necrosis in the affected humans and animals. Clinically, treating snakebite victims in Africa with clinically-approved anti-sera can efficiently reverse pathology by partially immunodepleting cytotoxins found in some *Naja* venoms.

Cytotoxins are non-enzymatic toxins and their mode of cytotoxicity involves their ability to form pores on cell membranes. While α-neurotoxins (from cobra venom) mainly exert their pathological effects by physically interacting with select protein receptors, no specific protein targets have yet been identified for cytotoxins from cobra venom [29]. Cytotoxins exhibit activity on various cell types, including erythrocytes, lymphocytes, cardiac myocytes, spleen cells, and various tumor cells [31]. The

pathological consequences, however, depend on the cell membrane proteins and phospholipids found on the outer leaflet of the plasma membrane of these cell types [32]. Cytolysis is considered to be the general mechanism of action [33].

Cardiotoxic effect

Some cytotoxins, also known as cardiotoxins, depolarize cardiac myocytes [34]. The mechanism of cytotoxicity induced by cardiotoxins in heart cells mainly involves the opening of voltage-dependent Ca^{2+} channels, leading to a block of the inwardly rectifying K^+ channels and the formation of new abnormal ion conductive pathways [27]. It has been suggested that these cytotoxins interact with protein targets in the membrane of cardiac myocytes [35]. Cardiotoxic venom causes cardiac toxicity that is deduced at autopsy since its effect is usually masked by the neurotoxic effect. However, autopsy results have shown effects on the heart similar to that seen in skeletal muscles. The sino-arterial node of the heart has been shown to be the most affected [36].

Type of Compound	Action on the Body	Snake Family
Acetylcholinesterases (AchE)	Believed to cause tetanic paralysis.	Colubridae, Elapidae
Arginine esterases	Believed to predigest prey.	Viperidae
Bradykinin-potentiating peptides (BPP)	Pain, hypotension, immobilize prey.	Viperidae
C-type lectins	Modulate platelet activity, prevent clotting.	Viperidae
Cysteine-rich secretory proteins (CriSP)	Believed to induce hypothermia, immobilize prey	Colubridae, Elapidae, Viperidae
Disintegrins	Inhibit platelet activity, promote hemorrhaging.	Viperidae
Hyaluronidases	Increase interstitial fluidity, aiding the dissemination of venom from the bite site	Elapidae, Viperidae
L-amino acid oxidases (LAAO)	Cell damage/apoptosis.	Elapidae, Viperidae
Metalloproteinases (MPr)	Hemorrhage, myonecrosis, believed to predigest prey.	Atractaspididae, Colubridae, Elapidae, Viperidae
Myotoxins	Myonecrosis, analgesia, immobilize prey.	Viperidae
Nerve growth factors	Believed to cause cell apoptosis.	Elapidae, Viperidae
Phosphodiesterases (PDE)	Believed to cause hypotension, shock.	Colubridae, Elapidae, Viperidae
Phospholipase A_2 (PLA_2)	Myotoxicity, myonecrosis, damage to cell membranes	Colubridae, Elapidae, Viperidae
PLA_2-based presynaptic neurotoxins	Immobilize prey	Elapidae, Viperidae
Prothrombin activators	Disseminated intravascular coagulation (DIC: small clots form throughout body, leading to uncontrolled bleeding), which can be fatal	Elapidae
Purines and pyrimidines	Believed to cause hypotension, paralysis, apoptosis, necrosis, immobilization of prey.	Elapidae, Viperidae
Sarafotoxins	Myocardial ischemia (reduced blood flow to heart), increase blood pressure, disturb heart rhythm.	Atractaspididae
Serine proteases	Hemostasis disruption, hypotension, immobilize prey	Colubridae, Viperidae
Three-finger toxins (3FTx)	Rapid immobilization of prey, paralysis, death.	Colubridae, Elapidae

Table 1: Primary snake venom compounds of concern to humans and animals.

The information in the Table 1 is modified from: Handbook of Venoms and Toxins of Reptiles. CRC Press/Taylor & Francis Group, Boca Raton, FL [37].

Necrotoxic effect

The necrotoxic venom is usually associated with proteolysis by the enzymes of the proteinase and metalloproteinase groups. Another protein that has been associated with necrotoxicity is myotoxins, which break down tissues and digest mammalian proteins especially those found in skeletal muscles leading to pains, swelling, pus formation, tissue necrosis and gangrene [20]. This feature is seen in most families of venomous snakes in West Africa and beyond.

Factor	Effect on outcome
Size of victim	Bigger the size, good is the outcome due to less amount of toxin per kg of body weight
Comorbidity	Predisposes to harmful effect of snake venom
Part bitten	Patients bitten on the trunk, face, and directly into bloodstream have a worse prognosis
Exercise	Exertion following snake bite has poor outcome due to enhanced systemic absorption of toxin
Individual sensitivity	Sensitivity of individual to venom modifies the clinical picture
Bite characteristics	Bite number; depth of bite; dry bite; bite through clothes, shoes, or other protection; amount of venom injected; condition of fangs; and duration for which snake clings to the victim, all affect outcome
Snake species	Different species have different lethal dose, lethal period, and aggressiveness
Secondary infection	Presence or absence of pathogenic organisms in the mouth of the snake
Treatment	Nature of first aid given and time elapsed before first dose of antivenom.

Table 2: Factors contributing to severity and outcome in snakebite [38].

No envenomation	**Absence of local or systemic reactions; fang marks (+/−).**
Mild envenomation	Fang marks (+), moderate pain, minimal local edema (0-15 cm), erythema (+), ecchymosis (+/−), no systemic reactions.
Moderate envenomation	Fang marks (+), severe pain, moderate local edema (15-30 cm), erythema and ecchymosis (+), systemic weakness, sweating, syncope, nausea, vomiting, anemia, or thrombocytopenia.
Severe envenomation	Fang marks (+), severe pain, severe local edema (>30 cm), erythema and ecchymosis (+), hypotension, paresthesia, coma, pulmonary edema, respiratory failure.

Table 3: Assessment of severity of envenomation [38].

Diagnostic Methods for Snake Envenomation

The diagnosis of snake bite or determination of which snake is responsible for envenoming of a victim can be conveniently divided into clinical diagnosis and laboratory diagnosis. Clinical diagnosis depends upon recognizing specific signs of envenoming in the patient. This includes local signs such as swelling, blistering, and local necrosis. More importantly for accurate diagnosis, systemic signs, such as haemorrhage, incoagulable blood, and hypovolaemic shock, are common mainly in viper bite, whereas neurotoxic signs occur primarily in elapid bite, and rhabdomyolysis (muscle damage) in sea snake bite although it should be noted that there are exceptions to this rule. For example, some Australian elapid venom can cause haemorrhage and incoagulable blood in addition to neurotoxicity and the venoms of some vipers, such as the tropical rattlesnake, Crotalus durissus terrificus, and the berg adder, *Bitis atropos*, can cause neurotoxic signs in systemically envenomed victims. It should also be noted that the presence or absence of fang marks are not diagnostic although the distance between the fang marks does provide an indication as to the size of the biting snake; however, the detection of fang marks does not necessarily indicate that venom has actually been introduced.

Cobra snakebite is frequently misdiagnosed and can lead to worsened local destructive lesions if left without specific antivenom treatment [39]. This was one of the major reasons which inspired the development of sensitive assay techniques using immunodiagnostic and other laboratory-based methods [40]. There are numerous serological procedures available for the detection of snake venom, including radioimmunoassay, agglutination assay, fluorescence immunoassay, and enzyme-linked immunosorbent assay (ELISA) [41].

(a) The 20 min whole blood clotting test (20 WBCT): The 20 WBCT is a simple bedside test of coagulopathy to diagnose viper envenomation and rule out elapid bite [42]. It requires a new clean, dry test tube made up of simple glass that has not been washed with any detergent. A few milliliters of fresh venous blood is drawn and left undisturbed in the test tube for 20 min; the tube is then tilted gently. If the blood is still liquid after 20 min, it is evidence of coagulopathy and confirms that the patient has been bitten by a viper. Cobras or kraits do not cause antihemostatic symptoms [43].

(b) Enzyme linked immunosorbent assay (ELISA): ELISA tests are now available to identify the snake species involved, based on antigens in the venom [44]. These tests, however, are expensive and not freely available and, thus, have limited value in diagnosis; at present, they find use mainly in epidemiological studies.

Other nonspecific tests include

i. Hemogram: The hemogram may show transient elevation of hemoglobin level due to hemoconcentration (because of the increased capillary leak) or may show anemia (due to hemolysis, especially in viper bites). Presence of neutrophilic ocalized is signifies systemic absorption of venom [45]. Thrombocytopenia may be a feature of viper envenomation.
ii. Serum creatinine: This is necessary to rule out renal failure after viper and sea snake bite.
iii. Serum amylase and CPK (creatinine phosphokinase): Elevated levels of these markers suggest muscle damage (caution for renal damage).
iv. Prothrombin time (PT) and activated partial thromboplastin time (aPTT): Prolongation may be present in viper bite.
v. Fibrinogen and fibrin degradation products (FDPs): Low fibrinogen with elevated FDP is present when venom interferes with the clotting mechanism.
vi. Arterial blood gas and electrolyte determinations: These tests are necessary for patients with systemic symptoms.
vii. Urine examination: Can reveal hematuria, proteinuria, hemoglobinuria, or myoglobinuria. (Arterial blood gases and urine examination should be repeated at frequent intervals during the acute phase to assess progressive systemic toxicity).
viii. Electrocardiogram (ECG): Nonspecific ECG changes such as bradycardia and atrioventricular block with ST-T changes may be seen [46].
ix. Electroencephalogram (EEG): Recently, EEG changes have been noted in up to 96% of patients bitten by snakes. These changes start within hours of the bite but are not associated with any features of encephalopathy. Sixty-two percent showed grade I changes, 31% cases manifested grade II changes (moderate to severe abnormality), and the remaining 4% showed severe abnormality (grade III). These abnormal EEG patterns were seen mainly in the temporal lobes [47].

(C) Lateral Flow Immunochromatographic Assay

Lateral flow tests (IVDT archive) [48] also known as lateral flow immunochromatographic assays, are simple devices intended to detect the presence (or absence) of a target analyte in sample (matrix) without the need for specialized and costly equipment, though many laboratory-based applications exist that are supported by reading equipment [49]. Typically, these tests are used

for medical diagnostics either for home testing, point of care testing, or laboratory use. A widely spread and well-known application is the home pregnancy test.

The technology is based on a series of capillary beds, such as pieces of porous paper, micro-structured polymer [50], or sintered polymer. Each of these elements has the capacity to transport fluid (e.g., urine) spontaneously. The first element (the sample pad) acts as a sponge and holds an excess of sample fluid. Once soaked, the fluid migrates to the second element (conjugate pad) in which the manufacturer has stored the so-called conjugate, a dried format of bio-active particles in a salt-sugar matrix that contains everything to guarantee an optimized chemical reaction between the target molecule (e.g., an antigen) and its chemical partner (e.g., antibody) that has been immobilized on the particle's surface. While the sample fluid dissolves the salt-sugar matrix, it also dissolves the particles and in one combined transport action the sample and conjugate mix while flowing through the porous structure. In this way, the analyte binds to the particles while migrating further through the third capillary bed. This material has one or more areas (often called stripes) where a third molecule has been immobilized by the manufacturer. By the time the sample-conjugate mix reaches these strips, analyte has been bound on the particle and the third 'capture' molecule binds the complex. After a while, when more and more fluid has passed the stripes, particles accumulate and the stripe-area changes color.

Typically, there are at least two stripes: one (the control) that captures any particle and thereby shows that reaction conditions and technology worked fine, the second contains a specific capture molecule and only captures those particles onto which an analyte molecule has been immobilized. After passing these reaction zones the fluid enters the final porous material, the wick that simply acts as a waste container. Lateral Flow Tests can operate as either competitive or sandwich assays.

Due to their simplicity, utility and relatively low production costs, membrane-based lateral flow assays have, over the last decade, become an important tool not only in medical diagnostics but also in veterinary diagnostics and in the environmental and agricultural fields.

Competitive assays

The sample first encounters colored particles which are ocaliz with the target analyte or an analogue. The test line contains antibodies to the target/its analogue. Unlabeled analyte in the sample will block the binding sites on the antibodies preventing uptake of the colored particles. The test line will show as a colored band in negative samples.

Sandwich assays

As the sample migrates along the assay it first encounters a conjugate, usually colloidal gold, which is ocalized with antibodies specific to the target analyte. If the target analyte is detected within the sample the conjugate antibodies will bind and subsequently reach the test line which also contains antibodies specific to the target. Once the sample reaches the test line and the target analyte is present a visual change, normally a line appearing, will occur allowing the test to be read as a positive. The majority of sandwich assays also have a control line which will appear regardless of whether or not the target analyte is present.

An example of the sandwich assay is the home pregnancy test which tests for hCG within the urine.

Colored particles

In principle, any colored particle can be used; however latex (blue color) or nanometer sized particles [51] of gold (red color) are most commonly used. The gold particles are red in color due to ocalized surface plasmon resonance.

Treatment of Snake Envenomation

Anti-snake venom (ASV)

Anti-snake venoms are the only effective specific treatment or antidotes for snake envenomation [14]. They are immunoglobulins prepared by immunizing horses with the venom of poisonous snakes and subsequently extracting and purifying the horses' serum. They are the only effective antidote for snake venom. Antivenoms may be species specific (monovalent/monospecific) or may be effective against several species (polyvalent/polyspecific). Antibodies raised against the venom of one species may have cross-neutralizing activity against other venoms, usually that from closely related species. This is known as paraspecific activity. As per the recommendations of WHO, the most effective treatment for snakebite is the administration of monospecific ASV [52]; however, this therapy is not always available to snakebite victims because of its high cost, frequent lack of availability, and the difficulty in correctly identifying the snake [53].

System	Clinical features
CVS	Spontaneous systemic bleeding
	Whole blood clotting time >20 min in the case of viper envenomation
	Thrombocytopenia
	Shock
	Hyperkalemia
	Arrhythmia
	Abnormal electrocardiogram
Neurological	Ptosis and paralysis
Renal	Acute renal failure
Musculoskeletal	Generalized rhabdomyolysis and muscular pains
	Local swelling involving more than half of the bitten limb
	Rapid extension of swelling
	Development of an enlarged lymph node draining the bitten limb

Table 4: Indications for anti-snake venom [38].

Conclusion

Snakebite remains a major medical problem among rural community of the savannah region of West Africa including Nigeria, as it is a leading cause of mortality and morbidity among farmers, pastoralists, hunters, children in these areas. Proper identification of snake and /or diagnosis will help in alleviating the severity of snakebite cases.

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