LAKESHORE ACCIDENTS IN THE BRAZILIAN AMAZON: CLINICAL AND ECO-EPIDEMIOLOGICAL ASPECTS

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Lachesis accidents in the Brazilian Amazon: clinical and eco-epidemiological aspects
Acidentes laquéticos na Amazônia brasileira: aspectos clínicos e ecoepidemiológicos

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ABSTRACT

Introduction: Ophidism, synonymous with snakebite accidents, refers to cases of envenomation resulting from snake bites. In Brazil, these incidents are classified into four basic types: Bothropic, Crotalic, Elapidic, and Lachesis envenomations.
Objective: This article aims to describe and discuss the most relevant aspects of Lachesis envenomation in the Brazilian Amazon.
Methodology: To achieve this objective, a literature review was conducted using a search strategy applied to the Lilacs, Scielo, and Pubmed databases. This search enabled the discussion of the following topics: (1) biology of Lachesis snakes, (2) ecology and epidemiology of Lachesis-related accidents, (3) pathogenesis, (4) natural history and clinical presentation, (5) differential diagnosis, (6) laboratory evaluation, (7) therapeutic approach, and (8) prevention and control.
Results: Lachesis venom exhibits proteolytic, hemorrhagic, and coagulant activity, with neurotoxic effects also reported, leading to various clinical manifestations. Management should be based on information obtained through a comprehensive anamnesis, detailed clinical observation, and laboratory tests (particularly coagulation time). Anti-Lachesis serum (ALS) or anti-Bothropic-Lachesis serum (ABLS) should be administered as early as possible to positively impact the victim's clinical progression.
Conclusion: Preventive measures should be implemented to minimize the risk of encounters between Homo sapiens and Lachesis snakes and, consequently, reduce the occurrence of envenomation.

Keywords: Amazonia; *Lachesis*; Pathogenesis, "Surucucu".

RESUMO

Objetivo: O presente artigo tem como objetivo descrever e discutir os aspectos mais relevantes do envenenamento por *Lachesis* na Amazônia brasileira. Metodologia: Assim, foi utilizada a estratégia de busca definida nas bases de dados Lilacs, Scielo e Pubmed. Esta busca permitiu a discussão dos seguintes temas: (1) biologia das serpentes do gênero Lachesis, (2) ecologia e epidemiologia do acidente laquético, (3) patogênese, (4) história natural e apresentação clínica, (5) diagnóstico diferencial, (6) avaliação laboratorial, (7) abordagem terapêutica e (8) profilaxia e controle. Resultados: O veneno laquético apresenta atividade proteolítica, hemorrágica e coagulante, sendo também relatada ação neurotóxica, com ocorrência de alterações clínicas relacionadas. As condutas devem ser adotadas com base nas informações obtidas por meio de anamnese completa, observação clínica detalhada e exames laboratoriais (principalmente tempo de coagulação). O soro antilaquético (ALS) ou soro antibotrópico-laquético (ABLS) precisa ser administrado o mais precocemente possível, o que tem um impacto positivo na evolução clínica. Conclusão: Medidas preventivas devem ser adotadas, minimizando o risco de encontro entre *Homo sapiens* e *Lachesis* e, consequentemente, a ocorrência de envenenamento.

Palavras-chave: Amazônia; *Lachesis*; Patogênese, “Surucucu”.

INTRODUCTION

Snakebite accidents are a public health problem in tropical countries, both because of their incidence and the morbidity and mortality they cause. Ophidism - a synonym for snakebite accidents - comprises cases of envenomation resulting from snake bites (Pinho and Pereira, 2001; Silva and Pardal, 2018; Câmara et al., 2020). These conditions are divided into four basic types in Brazil: botrópicos (accidents involving snakes of the genera *Bothrops* and *Bothrocophias*; jararaca, jararacuçu, urutu, caiçaca, comboia), crotálicos (accidents involving snakes of the genus *Crotalus*; cascavel); elapidic accidents (accidents involving snakes of the genera *Micrurus* and *Leptomicrurus;* true coral) and *lachesis* accidents (accidents involving snakes of the genus *Lachesis*) (Bernarde and Gomes, 2012; Brasil, 2020; Hammer, Feio and Siqueira-Batista, 2022).

The venomous snakes of greatest interest to public health in Brazil belong to the Viperidae and Elapidae families. The venom-inoculating apparatus of these animals consists of a pair of frontal teeth in the mandible, so that the dentition can be classified as solenoglyphic or proteroglyphic, respectively (Melgarejo, 2003). The Viperidae family includes snakes of the genus *Lachesis, which* cause lachrymal accidents. This genus, exclusive to the humid tropical forests of the New World, currently comprises four species: *Lachesis melanocephala* and *Lachesis stenophrys* present in Central America, Lachesis *acrochorda* also found in Bolivia and Ecuador (South America), and *Lachesis muta*, essentially in forest areas of the Amazon and Atlantic Forest, being the only species found in Brazil (Silva et al., 2019; Siqueira-Batista et al., 2020).

Animals of the species *Lachesis muta*, described by Linnaeus in 1766, are popularly called surucucu, surucucu-pico-de-jaca, surucutinga and malha-de-fogo; and by Americans, they are called *Bushmaster* (senhor do *mato*) (Silva et al., 2019; Cunha and Nascimento, 2020). With a total length of more than three meters, the surucucu is known as the longest viper in the Americas (Brasil, 2020; Rosenthal et al., 2002; Pardal et al., 2007). Surucu are oviparous, terrestrial, preferentially nocturnal and feed on small mammals (Martins and Oliveira, 1988).

Although little reported, accidents involving animals of the *Lachesis* genus can be quite representative in some regions of the Amazon (Bernarde and Gomes, 2012), despite the few

cases described in the literature. The natural *habitat of* animals of this genus of snakes is forested areas, with a low human population density and an often inefficient notification system, which corroborates the scarcity of records available on such events (Cunha and Nascimento, 1978; Brasil, 2001).

Despite the scarcity of data, it is essential for doctors to be able to recognize the clinical aspects of snakebites caused by snakes of the genus *Lachesis,* especially in the Amazon region, and to understand the importance of indicating the specific therapeutic approach for each case (Siqueira-Batista et al., 2007; Brasil, 2021), considering the unpredictability of the occurrence of snakebites. The aim of this study is therefore to review national and international scientific production on snakebite accidents caused by snakes of the genus *Lachesis* in the Brazilian Amazon.

METHODS

The literature search was conducted by defining the search strategy and selecting the articles, as described below.

SELECTION OF DESCRIPTORS

The descriptors used were consulted on the DeCS platform (Health Science Descriptors - https://decs.bvsalud.org/). After analyzing different possibilities, the following terms were chosen: "*Amazonian Ecosystem*"; "*Lachesis muta"*; "*Snake Bites"*; "*Viper Venoms"; "Amazon"; "Amazon region"* (Table 1).

SEARCH STRATEGY

The search for articles was carried out in the following electronic databases: Latin American and Caribbean Health Sciences Literature (Lilacs - www.lilacs.bvsalud.org), *Scientific Electronic Library Online* (SCIELO - www.search.scielo.org) and *U. S. National Library of Medicine (*PUBMED - www.pubmed.ncbi.nlm.nih.gov). Initially, we searched for original articles, with no date restriction, on topics related to the occurrence of accidents by *Lachesis* in the Brazilian Amazon.

Table 1. Search strategy used in the literature review and the results found in the databases. "*Amazonian Ecosystem*"; "*Lachesis muta*"; "*Snake Bites*"; "*Viper Venoms*"; *Amazon*"; *"Amazon region"*.

Search strategy (English)	LILACS	SciELO	PubMed
"*Amazonian Ecosystem*" AND "*Lachesis muta*"	1	0	0
"*Amazonian Ecosystem*" AND "*Snake Bites*"	3	0	0
"*Amazonian Ecosystem*" AND "*Viper Venoms*"	1	0	0
"*Lachesis muta*" AND "*Snake Bites*"	30	4	23
"*Lachesis muta*" AND "*Viper venoms*"	39	0	44
"Amazon" AND *"Lachesis muta"*	2	0	6
"Amazon" AND "*Snake Bites*"	16	0	60
"Amazon" AND *"Viper Venoms"*	5	0	5
"Amazon Region" AND *"Lachesis muta"*	1	0	3
"Amazon Region" AND *"Snake Bites"*	9	0	20
"Amazon Region" AND *"Viper Venoms"*	2	0	3

Source: Prepared by the authors (2024).

CHARACTERISTICS OF THE STUDY, SELECTION OF ARTICLES AND EXCLUSION/INCLUSION CRITERIA

The inclusion of studies was based on the following criteria: articles containing information on (i) eco-epidemiological aspects and/or (ii) the clinical elements of *Lachesis* accidents. In this sense, all manuscripts that covered at least one of the following items were excluded: texts with (a) a focus on animals other than snakes, (b) a theme focused on accidents by snake genera other than *Lachesis*; (c) accidents that occurred in areas other than the Amazon Region. The established date limit was 31/12/2020, with no language restriction.

SELECTION OF STUDIES AND DATA EXTRACTION

The articles selected for the study were systematized in three steps:

Step 1: The articles identified by the electronic search were organized and reviewed for duplicates by three independent reviewers.

Step 2: Three independent reviewers analyzed the titles and abstracts of the articles and disregarded those that did not meet the inclusion criteria. If there was insufficient data, the abstract was assessed in the next evaluation stage.

Step 3: The full texts of the articles selected up to this stage were retrieved and reviewed by three researchers, who selected the studies that discussed the etiological, pathophysiological, clinical, diagnostic, therapeutic, eco-epidemiological and/or prophylactic aspects of the *Lachesis* genus.

A protocol was defined for the extraction of data from the full texts, which was carried out by three reviewers, and the differences were decided by consensus between them. The following data was extracted and categorized from the studies: Authors, Date, Place, Objective, Methods, Results and Conclusion.

RESULTS

The initial data search retrieved 273 articles from the search platforms, of which: 109 from LILACS; 0 from Scielo, and 164 from Pubmed. After excluding the manuscripts according to the criteria presented, a total of 27 scientific articles were obtained. Book chapters, references cited in the selected articles and official documents from the Brazilian Ministry of Health were also consulted and complemented the search strategy. The texts were read, filed and the information obtained organized into topics - (1) biology of snakes of the genus *Lachesis*, (2) ecology and epidemiology of l*achesis* accidents, (3) pathogenesis, (4) natural history and clinical presentation, (5) differential diagnosis, (6) laboratory evaluation, (7) therapeutic approach and (8) prophylaxis and control (Chart 2).

BIOGEOGRAPHICAL ASPECTS

The only species recognized in the Brazilian Amazon, and throughout the country, is *Lachesis muta* (Fernandes, Franco and Fernandes, 2004) (Figure 1 and 2).

Table 2. Themes listed for discussion in the study.

TOPIC OF DISCUSSION	GUIDING ARTICLES
Snake biology	Ripa 2002; Rosenthal *et al.* 2002; Málaque 2003; Melgarejo 2003; Fernandes *et al.* 2004; Rodrigues et *al.* 2013.
Ecology and epidemiology	Cunha and Nascimento 1978; Haad 1981; Martins and Oliveira 1988; Carvalho Junior *et al.* 1994; Jorge et *al.* 1997; Siqueira-Batista et *al.* 2001; Melegarejo 2003; Argôlo 2003; Pardal *et al.* 2007; Bernarde and Gomes 2012; Câmara *et al.* 2020; Matos and Ignotti 2020; Souza 2020.
Pathogenesis	Jorge *et al.* 1997; Pinho and Pereira 2001; Siqueira-Batista et *al.* 2001; Azevedo-Marques *et al.* 2003; Málaque 2003; Fernandes *et al.* 2004; Cordeiro et al. 2018; Wiezel *et al.* 2019; De-Simone et *al.* 2021.
Natural history and clinical presentation	Amaral *et al.* 1991; Barravieira 1994; Pardal and Yuki 2000; Siqueira-Batista *et al.* 2001; Ripa 2002; Pardal and Dourado 2004; Torres-Filho 2015; Wiezel *et al.* 2019.
Differential diagnosis	Pinho and Pereira 2001; White 2017; Siqueira-Batista *et al.* 2020.
Laboratory evaluation	Barravieira 1994; Siqueira-Batista *et al.* 2020.
Therapeutic approach	Pinho and Pereira 2001; Siqueira-Batista *et al.* 2001; Ripa 2002; Pardal and Dourado 2004; Siqueira-Batista *et al.* 2007; Albuquerque et al. 2013; Das *et al.* 2015; White 2017; Grego et *al.* 2021; Muniz *et al.* 2021.
Prophylaxis and control	Gonçalves and Siqueira-Batista 2001; Pinho and Pereira 2001; Torres-Filho 2015; Silva and Pardal 2018; Silva *et al.* 2020; Siqueira-Batista *et al.* 2020.

Source: Prepared by the authors (2024).

DISCUSSION

BIOLOGY OF SERPENTS OF THE GENUS *Lachesis*

Taxonomy

Table 3. Taxonomy of the genus *Lachesis*.

CATEGORIES	SPECIES
Kingdom	Animalia
Phylum	Chordata
Class	Reptilia
Order	Squamata
Family	Viperidae
Subfamily	Crotalinae
Gender	*Lachesis*
Species	*Lachesis acrochorda, Lachesis melanocephala, Lachesis muta, Lachesis stenophrys*

Reproduced from (sources):
U.S. National Library of Medicine - NCBI Taxonomy
Encyclopedia of life
Taxonomic Catalog of the Fauna of Brazil
Available at:
https://www.ncbi.nlm.nih.gov/Taxonomy/Browser/wwwtax.cgi?mode=Info&id=8751&lvl=3&lin=f&keep=1&srchmode=1&unloc
https://eol.org/pages/35430

http://fauna.jbrj.gov.br

Figure 1: Illustrations of *Lachesis muta*

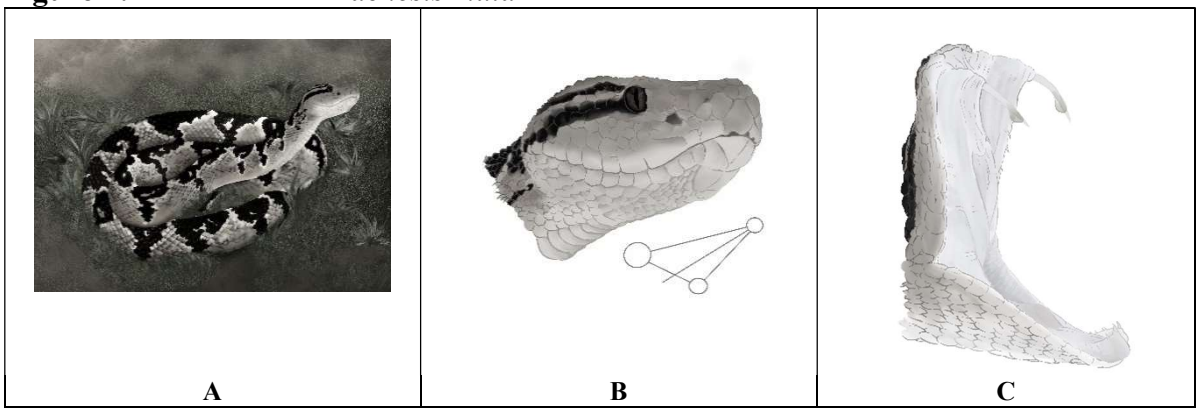

Figure 1. A - General view of the animal. B - Detail of the head. C - Detail of the teeth. Prepared by Ademir Nunes Ribeiro Júnior.

Figure 2: Photographs of *Lachesis muta*

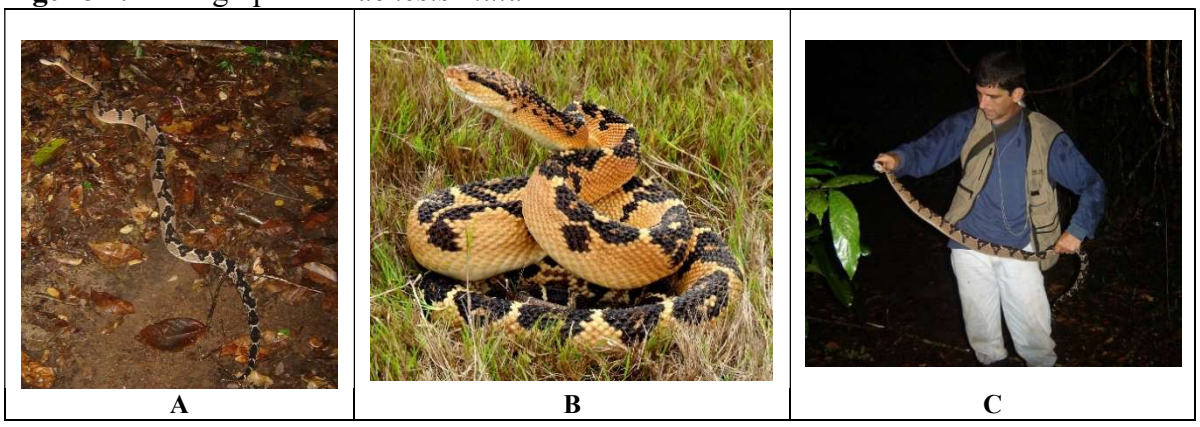

Figure 2. A - Image by Renato Feio (UFV), kindly provided. B - Image by Diego José Santana (UFMS), kindly provided. C - Image by Henrique C. Costa (UFJF), kindly provided.

Ecology and epidemiology of lachrymation

Snakes of the *Lachesis muta* species live exclusively in forested areas with moist soil, in floodplains and near streams, taking refuge in tree hollows and among the protruding roots of giant trees (Cunha and Nascimento, 2020). In the south and southeast of Bahia, they have been found in armadillo holes, in remaining forest patches, on their edges, or even in cocoa plantations adjacent to these fragments (Fernandes et al., 2004; Argôlo, 2003). They have terrestrial and nocturnal habits; they feed exclusively on small and medium-sized mammals, such as cuícas (*Monodelphis*), thorn rats (*Proechimys*), pacas (*Dasyprocta)* and squirrels (*Sciurus)* (Martins and Oliveira, 1988). The fact that they are found in forest areas - usually

with a low density of human occupation and a poor reporting system - means that relatively little information is available on these accidents (Silva and Pardal, 2018; Souza, 2020).

The surucus' strike can reach 50% of its total length, and a much greater height than those delivered by snakes of the genera *Bothrops* or *Crotalus,* representing a significant danger to visitors to these forests and justifying why they are extremely feared in their areas of occurrence (Silva et al., 2019). In captivity, contrasting behaviors have been observed in relation to their movement, being calm and slow routinely, but with surprising agility and speed of movement at dusk and in the mating period (August) (Melgarejo, 2003; Matos and Ignotti, 2020).

The state of Amazonas is home to the highest rates of morbidity, mortality and fatality due to snakebite accidents, especially due to the inherent difficulties in accessing care. These figures may be even higher in the Brazilian Amazon. This situation can be explained by the activities carried out in most municipalities in the state of Amazonas, which include plant extraction and agriculture. In addition, the difficulty of transporting the patient can result in late application of the antileukemic serum, interfering with the patient's prognosis (Silva and Pardal, 2001).

Thus, in Amazonas, the lethality rate of around 1% associated with snakebite accidents is higher than the national average of 0.4%. In the state, the problem of underreporting is aggravated by the great distances, traveled only by river, with countless localities with an unknown epidemiological profile. The occurrence is at least six times higher than the notification data (Silva and Pardal, 2001).

It is important that every snakebite accident is reported. Between 2014 and 2019, 1,269,803 snakebite accidents were recorded in Brazil. In 2019, 265,701 snakebite accidents were reported on SINAN (Notifiable Diseases Information System). The northern region recorded 21,008 cases of snakebite, approximately 3% of which were caused by animals of the *Lachesis* genus. Of the 620 cases recorded in the North, the state of Amazonas had the highest percentage, with 51% of the cases, accounting for 319 records of snakebite accidents caused by the surucucu (Table 4). Also, according to data from the Ministry of Health, in 2019, two patients died from the reported disease, 307 were cured and the rest did not complete the record, being listed as unknown/white.

Of the total number of snakebite accidents in 2019, 404 occurred in the 20 to 59 age group, with 60% between 20 and 39 and 40% between 40 and 59. In the state of Amazonas, the

age group most affected by this type of accident was between 20 and 39 years old, which consists of the economically active population. In relation to gender and age, of the 620 cases of lacquers in 2019 in the North, more than 497 cases were reported in males, 53.0% in the state of Amazonas.

In 2019, only 64% of reported cases were treated between 0 and 6 hours after the accident. It is important that the victim is cared for quickly, since the severity of the morbid condition is generally related to the time between the accident and the administration of serotherapy (Pinho and Pereira, 2001; Brasil, 2021).

Lachesis accidents are classified as moderate or serious. Because they are large snakes, the amount of venom injected by surucus is potentially very large. Severity is assessed according to local signs and the intensity of systemic manifestations (Brasil, 2001). The course of treatment for lachesis is based on the severity of the accident. In line with other studies found in the literature, 2019 data from SINAN indicate that more than 50.0% of cases were of moderate severity (Pardal et al., 2007; HAAD, 1980; Carvalho Júnior et al., 1994; Jorge et al., 1997).

Table 4. Number of lachrymation accidents in the last ten years, by state, in Brazil.

Year of the accident	RO	AC	AM	RR	PA	AP	TO	MA	MT
2010	23	105	335	37	374	38	5	15	45
2011	16	77	302	26	443	44	3	8	31
2012	16	77	315	40	319	36	5	5	22
2013	22	93	373	34	290	34	4	4	35
2014	26	102	334	29	201	43	1	15	17
2015	13	72	333	16	175	36	2	8	24
2016	7	35	239	22	129	24	-	3	19
2017	8	39	209	14	115	29	3	10	12
2018	9	35	254	23	124	33	2	11	8
2019	16	58	288	27	114	40	1	8	13
2020	7	36	236	21	88	15	2	11	10
2021	3	25	128	25	62	16	2	14	12
Total accidents	166	754	3.346	314	2.434	388	30	112	248

Source: Data-Sus (2020), public access.

Snakebite accidents also have the capacity to cause limb amputations, which can have a significant impact on the affected person's ability to work. In general, the countryside population - especially rural workers - is often affected by snakebites. This higher occurrence

is due to the fact that they are more frequently exposed to these animals and because, most of the time, they do not have (or do not use) the minimum safety resources (Brasil, 2014).

PATHOGENESIS: THE EFFECTS OF VENOMS

The surucucu has a venom capable of producing significant physiopathological repercussions. The main aspects of pathogenesis stem from the venom's proteolytic, hemorrhagic and coagulant activities. A neurotoxic action has also been reported; however, to date, the specific fraction of the venom responsible for this activity has not been isolated (Siqueira-Batista et al., 2020).

Proteolytic

Proteolytic activity is an acute inflammatory action, responsible for the alterations that occur at the site of the bite and in the surrounding area (Brasil, 2014). Lac venom has a proteolytic action, producing tissue damage. This action can also be called cytotoxic. The mechanisms that produce tissue destruction are probably the same as those of botropic venom, since proteolytic activity can be proven *in vitro* by the presence of proteases in both cases (Pinho and Pereira, 2001; Brasil 2001; Azevedo-Marques, Cupo and Hering, 2003; Cordeiro et al., 2018; Wiezel et al., 2019).

Local alterations - such as edema, blisters and necrosis - initially attributed to proteolytic action, have a complex pathogenesis. They are possibly due to the activity of proteases, hyaluronidases and phospholipases, the release of mediators of the inflammatory response, the action of hemorrhagins on the vascular endothelium and the procoagulant action of the venom. In more serious situations, the release of vasoactive mediators - such as bradykinin - can trigger shock (Pinho and Pereira, 2001; Fernandes, Franco and Fernandes, 2004; Azevedo-Marques, Cupo and Hering, 2003; Cordeiro et al., 2018).

Hemorrhagic and Coagulant

Experimental work has shown the intense hemorrhagic activity of *Lachesis muta* venom, with "*thrombin-like*" activity - coagulant action - causing afibrinogenemia and blood incoagulability (Azevedo-Marques, Cupo and Hering, 2003; De-Simone et al., 2021). The

venom of *Lachesis* species transforms fibrinogen into fibrin, forming microthrombi (small clots). In fact, the coagulant action derives from the thrombin-type fraction of the venom, which causes disturbances in blood crase. In these patients, the blood may be incoagulable due to the consumption of fibrinogen, whose low serum values, together with changes in prothrombin time (PT) and activated partial thromboplastin time (APTT), confirm the existence of coagulant activity (Brasil, 2021; Azevedo-Marques, Cupo and Hering, 2003).

The processes involved in this coagulant action differ from the thrombin mechanism, since it cannot be antagonized by the administration of heparin. Activated factor X leads to the utilization of platelets and factors V and VIII, which can result in disseminated intravascular coagulation and the deposition of microthrombi on the wall of capillary vessels, which usually leads to acute renal failure. The most common sites of bleeding are the gastrointestinal tract, the central nervous system, the airways and the skin. In the nervous system, bleeding can manifest as intracranial hemorrhage and possible development, in complicated cases, of a stroke (White, 2017).

Neurotoxic

A vagal stimulation-type action has been described, but the specific fraction of the venom responsible for this activity has not yet been characterized. The following have been reported: systemic arterial hypotension, dizziness, darkening of the eyes, bradycardia, hypersalivation, abdominal cramps and diarrhea (vagal syndrome), as well as changes in sensitivity at the site of the bite, taste and smell (Pinho and Pereira, 2001; Siqueira-Batista et al., 2020; Brasil, 2001; Jorge et al., 1997).

NATURAL HISTORY AND CLINICAL PRESENTATION

The clinical picture generally depends on the type of venom, taking into account three aspects in particular: the toxic actions, the amount inoculated and the body area affected.

Accidents caused by animals of the *Lachesis* genus have clinical repercussions very similar to those observed in events caused by snakes of the *Bothrops* genus. This is due to the fact that the local disorders - inflammatory signs of heat, edema, pain and redness (with the possibility of progression to necrosis) - are caused by proteolytic action, very similar to that found in botropic venom, and therefore have very similar consequences, which are potentially serious. In lachrymal accidents, the outcomes can be even more critical, for example due to the

large amount of venom inoculated, as the animals are generally larger than snakes of the *Bothrops* genus (Ripa, 2002). In addition to its proteolytic actions, venom has hemorrhagic and neurotoxic activity and can cause vomiting, abdominal pain, diarrhea and bradycardia, caused by vagal disturbance, systemic arterial hypotension and, in some cases, shock, findings that, once present, help in the clinical differentiation of accidents caused by *Bothrops* (Siqueira-Batista et al., 2020; Cordeiro et al., 2018; Ripa, 2002; Barravieira, 1994).

In mild lacquers, the victim usually has slight edema around the bite, as well as mild or absent hemorrhagic manifestations. In moderate cases, there is obvious edema and slight bleeding, such as gingivorrhea and epistaxis. In mild and moderate cases, there are usually no vagal manifestations; unlike severe accidents, which are characterized by intense oedema, systemic manifestations such as major bleeding, as well as vagal disturbances (Pardal and Yuki, 2000).

Complications

Patients suffering from snakebite should be properly monitored, considering the risk of possible complications, such as secondary infection, ulcerations with necrosis and compartment syndrome, which are discussed briefly below (Barravieira, 1994; Torres-Filho, 2015).

Secondary infection *is* an event that can occur in up to a fifth of patients victimized by the *Lachesis*, *Bothrops* and *Bothrocophias* genera. The main manifestations presented by the patient due to this condition are: fever, regional lymphadenitis and recrudescence of local inflammatory signs, in a patient who had already shown improvement in his condition. Among the most relevant microorganisms for the occurrence of this condition are the bacteria present in the snake's oral cavity (usually Gram-negative and anaerobic pathogens) and those from the patient's skin microbiota (more commonly Gram-positive) (Torres-Filho, 2015).

In this context, the most important pathogens include: *Morganella morgani*, *Enterobacter* spp., *Escherichia coli*, *Klebsiella* spp., *Providencia* spp., *Aeromonas hydrophila,* anaerobes and, less commonly, *Staphylococcus aureus and Staphylococcus epidermidis* (Siqueira-Batista et al., 2020). It is important to note that in these cases, local cellulitis can develop, which can evolve into the formation of abscesses. For treatment, it is very important to use antimicrobials based on the observation of bacterioscopy, by the Gram method, or by

culture obtained from closed collections. However, if these tests are not possible, immediate empirical treatment can be carried out, with amoxicillin combined with clavulanic acid; or clindamycin (or oxacillin + crystalline penicillin) combined with an aminoglycoside or quinolone. However, the abscesses formed should be drained and the material obtained should be examined so that antimicrobial therapy can be used appropriately.

For the treatment of **ulcerations with necrosis,** considering the proteolytic action of the venom, local drainage should be carried out, with subsequent assessment of the need for grafts (the opinion of the plastic surgeon, on these occasions, can be of great value).

Finally, there is **compartment syndrome**, which is defined by the occurrence of vascular compressive phenomena caused by intense muscular edema, and characterized by paresthesia, continuous pain, hypoesthesia, edema and stiffening of the affected region. In this situation, it is essential that the victim is thoroughly diagnosed using complementary tests, such as the use of *Doppler ultrasound,* to confirm the reduction in blood flow in the area. As far as treatment is concerned, a fasciotomy is indicated; the patient's possible blood incoagulability should be taken into account, considering the need for surgery.

Differential diagnosis

In order to correctly determine the diagnosis - excluding other hypotheses - a thorough anamnesis and clinical assessment are essential. After this assessment, it will be possible to determine the best therapeutic protocol and the specific serotherapy to be administered, in order to ensure greater effectiveness in treatment and a better prognosis for the patient (Pinho and Pereira, 2001; Brasil, 2021). In relation to rhabdomyolysis, other nosological entities should also be considered, such as causes due to traumatic compression and non-traumatic strain (White, 2017).

LABORATORY EVALUATION

Determining the snake involved in the snakebite accident can be very useful, although it is not essential for dealing with the case. Therefore, observation of the clinical picture is the most important aspect in terms of diagnosis. Due to the similarity of the clinical pictures between accidents caused by the *Bothrops* and *Lachesis* genera, there can be diagnostic confusion. However, considering the speed of action of the venoms and the time required to

obtain laboratory test results, decisions are made based on a complete anamnesis and detailed clinical observation, so that the laboratory tests requested are used especially for monitoring the affected patient (Siqueira-Batista et al., 2020; Gonçalves and Siqueira-Batista, 2001).

Clotting time

The most widely used and most important laboratory test in the case of snakebite accidents is the coagulation time test (TCoag). This test is widely used because it is simple and can be carried out even in places that don't have a laboratory. This analysis is of great importance due to the coagulating action of the venom, and it can also be used to assess the effectiveness of the serotherapy given to the patient. The interpretation of the TCoag should be based on the normal clotting time (less than or equal to 10 minutes), so that between 10 and 30 minutes it is classified as prolonged and above 30 minutes the test is characterized as incoagulable. With treatment, the coagulation time is expected to normalize within 12 hours; if this doesn't happen, another dose of serum should be administered (Gonçalves and Siqueira-Batista, 2001; Siqueira-Batista et al., 2001).

Blood count and ESR

The blood count - together with the TCoag - is useful when dealing with patients who have suffered an ophidian envenoming. This test allows us to identify a possible leukocytosis with a left shift and relative lymphopenia, which can be followed by thrombocytopenia. Another significant finding is the moderately increased erythrocyte sedimentation rate (ESR) in these cases (Das, Sankar and Dev, 2015).

Biochemical evaluation

In snakebites caused by the genus *Lachesis*, testing for abnormal elements and evaluation of the urinary sediment can reveal glycosuria, proteinuria, leukocyturia and hematuria in the most serious events. There may also be an increase in muscle enzymes - such as creatine phosphokinase (CPK), aspartate aminotransferase (AST) and lactate dehydrogenase (DHL) - usually not as significant as those found in crotillic accidents (Brasil, 2021; Barravieira, 1994).

In lachrymal, botropic and crotalic accidents, it is mandatory to assess kidney function, which should include the measurement of nitrogenous slags, such as urea and creatinine, and the measurement of electrolytes (chlorine, potassium and sodium), in order to detect hydroelectrolytic disorders early on, and thus verify the need for dialysis therapy in cases of acute renal failure (Brasil, 2021; Barravieira, 1994).

THERAPEUTIC APPROACH

At the scene of the accident, it is important to take certain measures. Initially, the patient should be removed from the area where the accident occurred in order to prevent further snake accidents. It is also important to calm them down, remove any props from the injured area and ensure that they remain as still as possible (White, 2017).

Specific treatment consists of administering antilacetic serum (SAL) or antibotropic-lactic serum (SABL) as early as possible (Pinho and Pereira, 2001; Brasil, 2021; Grego et al., 2021). The amount of serum to be applied is based on an approximate calculation of the amount of venom injected by the snake, which is estimated based on an analysis of the clinical manifestations presented by the patient (Torres-Filho, 2015; Siqueira-Batista et al., 2001; Das, Sankar and Dev, 2015). In fact, in moderate cases - local symptoms present, with or without bleeding, without vagal manifestations - 10 ampoules of SABL should be applied. While in severe cases - intense local symptoms, heavy bleeding, with vagal manifestations - 20 ampoules should be applied (Brazil, 2021).

It should be administered in a single dose, intravenously, and may or may not be diluted in isotonic solution. The serum can cause serious adverse reactions, such as anaphylactic shock, which makes it necessary to have drugs available to reverse these effects, as well as material for ventilatory assistance and access to the venous route. In addition, epinephrine should be administered promptly, and supplementary oxygen and monitoring of cardiopulmonary status may be necessary in very severe patients (De-Simone et al., 2021). The patient should remain in hospital for at least 72 hours after the bite for clinical and laboratory assessment (Pinho and Pereira, 2001). It is also essential that the health professional keeps the patient under observation throughout the administration of serotherapy (Siqueira-Batista et al., 2020). A risk-benefit assessment of serum administration is essential in cases where the patient has a history of serious adverse reactions to the use of serum, so its use should be discussed.

As mentioned above, the lachesis venom has proteolytic, coagulant, hemorrhagic and neurotoxic actions, responsible for different clinical manifestations, from local to systemic (Pinho and Pereira, 2001). Therefore, given the obvious risk of acute renal failure, the patient must be hydrated thoroughly and abundantly. To reduce local edema, the limb affected by the bite should be elevated after serotherapy. The use of potassium permanganate is also valid, and the drug should be diluted in a ratio of 1:40,000. It is also very important to assess whether antimicrobial therapy is indicated in cases of secondary infection. If the patient shows signs of shock, measures for circulatory failure should be established and, in cases of renal failure, dialysis treatment should be instituted (Siqueira-Batista et al., 2007).

For a good response to treatment, serotherapy should be instituted as early as possible (Brasil, 2020). The effectiveness of the treatment can be checked by examining the clotting time (TCoag) (Brasil, 2021; Muniz et al., 2021). If, after 24 hours of serotherapy, the blood is still incoagulable for up to 24 hours, a new dose capable of neutralizing 150 mg of venom should be applied. In most cases of acute renal failure caused by tubular necrosis, complete reversal of the condition is observed, unlike cortical necrosis, in which no such reversal is observed (Barravieira, 1994; Albuquerque et al., 2013).

PROPHYLAXIS AND CONTROL

In order to reduce snakebite accidents, it is important to take certain precautions. These include advising people to protect their lower limbs with boots when going to places where there is a high incidence of snakebites; observing the environment when walking in places where there is a possibility of encountering ophidians; wearing gloves when farming; cleaning up around the home; guidance on the nocturnal habits of snakes and always avoiding handling these animals (Pinho and Pereira, 2001; Torres-Filho, 2015; Gonçalves and Siqueira-Batista, 2001).

CONCLUSION

Epidemiology shows high morbidity and lethality from accidents caused by snakes of the *Lachesis* genus in the Amazon region, as well as problems related to notification and access to care in some locations. These morbid events are characterized by the large amount of venom inoculated - which usually produces marked proteolytic, hemorrhagic and coagulant activity -

with important clinical repercussions. The patient may present local and/or systemic manifestations and, in severe cases, may develop intense edema, major hemorrhage and vagal disorders. For all these reasons, it is essential to recognize the clinical aspects of these animals' attacks so that the correct treatment, with antilacetic serum (SAL) or antibotropic-lactic serum (SABL), can be instituted as early as possible. The patient should also be monitored to avoid possible complications. Finally, in order to reduce the number of these accidents, it is essential that prophylactic measures are adopted.

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