Pediatric scorpionism: a descriptive, cross-sectional, and retrospective study of predictors of severity

Santiago Suasnábar[a,b], *Claudia Godoy*[a], *Andrea Forchino*[a], *Gustavo Armando*[c,d]

ABSTRACT

Introduction. Scorpion envenomation by *Tityus carrilloi n. sp.* represents a threat to life. Depending on its clinical manifestations, it is classified as mild, moderate or severe.

Objective. To compare the epidemiological and biochemical characteristics among children with mild, moderate, and severe scorpionism.

Population and methods. Descriptive, cross-sectional, and retrospective study. The consultations at a tertiary care children's hospital in Santa Fe (Argentina) of children under 15 years of age stung by *Tityus carrilloi n. sp.* between January 2017 and December 2018 were analyzed.

Results. In total, 524 children were included, 81% (421) with local pain and 19% (103) with systemic manifestations. Children with systemic symptoms of scorpionism were younger in age than those with local manifestations ($p < 0.001$). In the winter, children developed 8 times more systemic manifestations of scorpionism; during the spring, 2.4 times more than during the summer.

Out of the 103 hospitalized children, 80 were moderate cases and 23 severe cases. There were no differences between age groups ($p = 0.29$) or in the delay in receiving the anti-scorpion serum ($p = 0.81$). The length of hospital stay was longer among severe cases ($p < 0.001$).

WBC and blood glucose levels higher than 30 000 cell/mL and 300 mg/dL, respectively, were present almost exclusively in severe scorpionism cases.

Conclusion. In children stung by the scorpion *Tityus carrilloi n. sp.*, the younger the age and during winter and spring, the higher the risk for systemic manifestations. WBC and blood glucose levels were higher in children with severe scorpionism.

Key words: *scorpion sting,* Tityus carrilloi n. sp., *clinical manifestations, pediatrics, epidemiology.*

http://dx.doi.org/10.5546/aap.2022.eng.377

To cite: Suasnábar S, Godoy C, Forchino A, Armando G. Pediatric scorpionism: a descriptive, cross-sectional, and retrospective study of predictors of severity. *Arch Argent Pediatr* 2022;120(6):377-383.

a. Hospital de Niños Dr. Orlando Alassia, Santa Fe, Argentina.
b. Center for Research on National Endemics (Centro de Investigaciones sobre Endemias Nacionales, CIEN), School of Biochemistry and Biological Sciences, Universidad Nacional del Litoral, Argentina.
c. Department of Health Programs, National Institute of Respiratory Diseases Dr. Emilio Coni, Santa Fe, Argentina.
d. Department of Mathematics, School of Chemical Engineering, Universidad Nacional del Litoral, Santa Fe, Argentina.

E-mail address:
Santiago Suasnábar: smsuasnabar@hotmail.com

Funding:
None.

Conflict of interest:
None.

Received: 11-9-2021
Accepted: 3-7-2022

INTRODUCTION

Scorpion envenomation is a life-threatening clinical condition, particularly in the pediatric population. It is a public health problem in different regions of the world with tropical or subtropical climates, such as Saharan Africa, India, the Middle East, Mexico, and South America.[1]

In Argentina, there are about 45 species of scorpions; *Tityus carrilloi n. sp.* is the most important from a clinical point of view.[2–4] The species circulating in Argentina has recently been identified (*Tityus carrilloi n. sp.*) differentiating it from the species that is predominant in Paraguay and the south of Brazil (*T. trivittatus*).[5]

Envenomation by these arachnids causes local and systemic symptoms. The condition is mild if there is burning pain at the site of the bite without systemic manifestations.[3] In moderate cases, vomiting, sweating, rhinorrhea, coldness in the extremities, tachycardia, tachypnea, and arterial hypertension are also present. When, in addition, there is compromise of the state of consciousness, use of accessory muscles for breathing, bradycardia and/or hemodynamic compromise, it is classified as severe scorpionism.

In pediatrics, 80-85% of *T. carrilloi n. sp.* stings are mild.[6] Treatment consists of relieving pain and keeping the child under observation for a period of 6 hours.[3] In the remaining 15-20% of cases who develop systemic manifestations of envenomation, the administration of the specific antidote is critical.

Hospital de Niños Dr. Orlando

Alassia receives referrals of children under 15 years of age from the central and northern districts of the province of Santa Fe, an area with approximately 1 million inhabitants, out of whom between 200 000 and 250 000 are children.[7] Since the 1970s, there have been references about children hospitalized in Santa Fe due to scorpion stings, and the first publications about envenomation in our region were first made in 1990.[8] Years later, a series of cases of children admitted to the intensive care unit because of severe envenomation by *T. trivittatus* were reported.[9]

The objective of this study was to compare epidemiological and laboratory characteristics among children under 15 years of age with mild, moderate or severe scorpionism from the central and northern districts of the province of Santa Fe. The working hypothesis was that there were factors associated with severity that behaved as predictors of clinical course.

POPULATION AND METHODS

This was a descriptive, cross-sectional, and retrospective study. The medical records of children who consulted for stings by *Tityus carrilloi n. sp.* at Hospital Dr. Orlando Alassia between January 1st, 2017 and December 31st, 2018 were assessed.

Children were treated by an emergency pediatrician. There are pictures of scorpion species in the outpatient emergency service to facilitate their identification. The diagnosis of a *T. carrilloi n. sp.* sting was based on the presence of the scorpion specimen, the history of a scorpion sting whose description matched its typical characteristics, or a sudden onset of symptoms with characteristic clinical and laboratory manifestations, even in the absence of a specimen.

Data were recorded in two ways: a) the emergency pediatrician entered care data in the Diagnose® software and b) the Epidemiology Service recorded scorpionism cases in a spreadsheet on a daily basis.

Children under 15 years of age diagnosed with *T. carrilloi n. sp.* sting within 6 hours of the event and for whom at least the date, place of origin, age, and sex were available were included in the study.

Cases were excluded when: a) the scorpion could not be identified and b) patients did not meet the three characteristic laboratory abnormalities (hyperglycemia, hypokalemia, and metabolic acidosis) in the absence of the scorpion, even if clinical manifestations were present.

The following data were collected for all children: age, sex, date, place of origin, and hospital stay. In those patients with systemic manifestations (moderate and severe cases), medical records and epidemiological files were reviewed to obtain the time of day when the sting occurred, the part of the body stung, the circumstances in which it occurred, the presence of comorbidities, the length of delay in the administration of an anti-scorpion serum, white blood cell count, platelet count, blood glucose, potassium, blood urea, acid-base status, blood amylase, creatine phosphokinase (CPK), alanine aminotransferase (GPT), and length of hospital stay.

Among children with local manifestations (mild scorpionism) and those with systemic symptoms (moderate and severe scorpionism), a comparison of sex, age, date of sting, and place of origin was made. The date was stratified into the 4 seasons of the year. The association of variables was analyzed by estimating odds ratios using multiple logistic regression. In addition, the likelihood of developing systemic manifestations in terms of age and seasonality was calculated.

On the other hand, epidemiological and laboratory data were compared between children with moderate symptoms of scorpionism and those with severe manifestations.

Continuous variables were expressed as mean or median, while categorical variables, as proportions. Non-parametric bootstrap and comparison of means by the permutation test were used to construct confidence intervals. Fisher's test was used to analyze categorical variables.

For laboratory parameters where differences were observed between moderate and severe scorpionism, a ROC curve analysis was performed to establish the cut-off point.

In all cases, a value of $p \leq 0.05$ was considered statistically significant.

The Stata® v12 or R 4.1.1 software programs were used for statistical analysis and GraphPad Prism® 5 for graphs.

Ethical considerations

The study protocol was approved by the Committee for the Assessment of Scientific Studies and Teaching of Hospital de Niños Dr. Orlando Alassia and complied with the principles of the Declaration of Helsinki.

RESULTS

The medical records of 532 children diagnosed with scorpion sting were analyzed; and 8 were excluded: in 7, it was not possible to accurately determine the history of the sting; the remaining child received anti-scorpion serum and it was later determined they were symptoms of a different etiology.

A total of 524 children stung by *T. carrilloi n. sp.* met the inclusion criteria; of these, 421 (80.3%) had mild symptoms and 103 (19.7%), moderate or severe manifestations. Of the 103 children who required treatment with anti-scorpion serum, scorpionism was classified as moderate in 80 and severe in 23.

The mean age of children was 7.1 ± 4.2 years. Eighty three percent of stings occurred during spring and summer seasons (*Figure 1*).

Age behaved as a variable associated with the development of systemic manifestations. For every year of increase in age, the likelihood of having moderate or severe scorpionism decreased by 11% (*Table 1*).

Children from locations outside the city of Santa Fe had moderate/severe symptoms twice as often as those from the city itself.

FIGURE 1. *Monthly distribution of cases of scorpionism in central and northern districts of Santa Fe during 2017-2018*

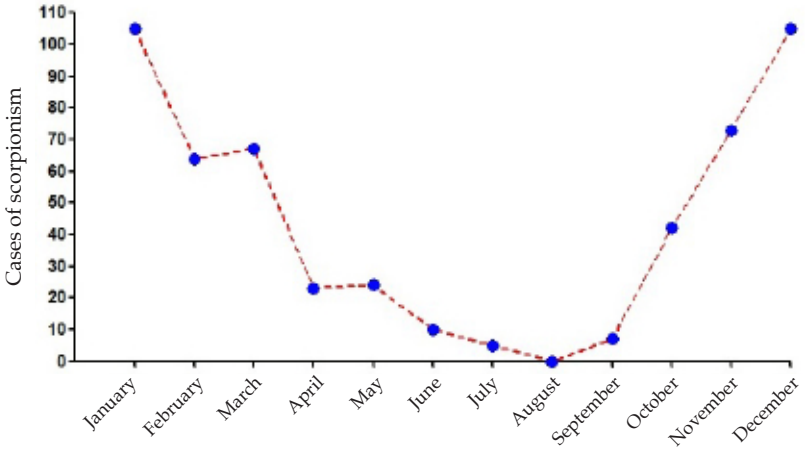


TABLE 1. *Distribution of the severity of scorpionism cases according to sex, age, place of origin, and seasonality (n = 524)*

	Scorpionism			Logistic regression		
	Mild (n = 421)	**Moderate/severe (n = 103)**	***p* value**	**OR**	**95% CI**	***p* value**
Sex						
Male	230 (44)[a]	50 (9.5)	0.26	0.67	0.42-1.06	0.09
Female	191 (36.4)	53 (10.1)		1		
Age (years)	7.5 ± 4.2	5.6 ± 3.7	< 0.001	0.89	0.84-0.95	< 0.001
Place of origin						
Santa Fe	372 (71)	76 (14.5)	< 0.001	1		
Other city	49 (9.3)	27 (5.2)		2.1	1.31-2.11	< 0.001
Seasons						
Summer	231 (44.3)	40 (7.7)	0.003[b]	1		
Fall	63 (12)	13 (2.5)		1,2	0.59-2.47	0.60
Winter	5 (1)	6 (1.1)		8,18	2.32-28.85	< 0.001
Spring	122 (23)	44 (8.4)		2,40	1.44-3.99	0.001

[a] The percentage of the total number of cases for categorical variables is expressed between parentheses.
[b] Fisher's test was performed between the 2 groups with the greatest difference (summer and winter).
OR: odds ratio; CI: confidence interval.

Stings occurring during the winter developed 8 times more scorpionism symptoms, and those occurring during the spring, 2.4 times more than in the summer.

The likelihood of developing systemic manifestations had a similar variation according to age in all seasons of the year (*Figure 2*); however, stings during winter among children under 2 years of age were 60–70% likely to develop systemic symptoms, while for the same age range it decreased to 20-30% during summer.

On the other hand, epidemiological and laboratory characteristics were compared between children with moderate scorpionism and those with severe manifestations (*Table 2*). Most of the cases occurred overnight, between 12 am and 8 pm, while the children were sleeping or walking barefoot.

The delay in administering anti-scorpion serum was greater in severe cases compared to moderate ones, although the difference between both was not statistically significant. The length of hospital stay was longer in patients with severe scorpionism, with a significant difference between groups.

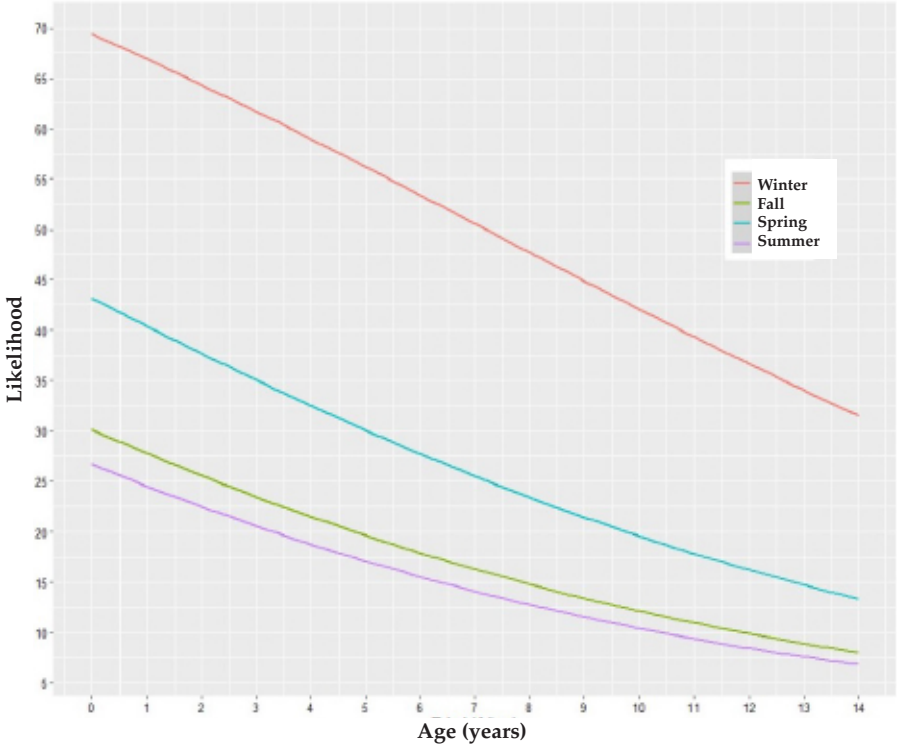
In the 23 severe cases, white blood cell, platelet, blood sugar, potassium, blood urea, acid-base status, and amylase levels were obtained. CPK and GPT determinations were performed in 20 and 15 cases, respectively.

Children with severe scorpionism had higher white blood cell counts and blood glucose levels than those with moderate manifestations. Conversely, pCO_2 and bicarbonate levels were lower among children with severe scorpionism compared to those with a moderate condition.

When performing ROC curves, a cut-off point of 30 300 white blood cells resulted in a sensitivity of 17.4% and a specificity of 93.1%, which allowed to correctly classify 75% of individuals. As far as blood glucose, a cut-off value of 306 mg/dL obtained a sensitivity of 26.1% and a specificity of 96%, correctly classifying 79.6% of the cases (*Figure 3*).

Seventeen children were admitted to the pediatric intensive care unit (16 severe, 1 moderate) and 53 children were admitted to the intermediate care unit (7 severe, 46 moderate). The remaining 33 children (moderate) were admitted to the intermediate care ward.

FIGURE 2. *Likelihood of developing systemic manifestations of scorpionism depending on the age and season of the year in which the sting occurs*



Of the 103 children, 15 had some type of comorbidity: 9 with a history of recurrent obstructive bronchitis, 1 with obesity, 1 with obesity and intestinal polyposis, 2 with a history of febrile seizure, 1 girl with mild persistent asthma, 1 girl with bilateral pyelocaliceal dilatation due to a double excretory system and 1 boy with a history of a single ventricle subjected to the Glenn procedure.

No child died.

DISCUSSION

The results of this study confirm the importance of scorpionism by *T. carrilloi n. sp.* as a health problem in the pediatric population in our region. During 2 years, over 500 consultations were recorded; 1 out of 5 children required hospitalization, and 23 of these hospitalizations corresponded to severe cases with hemodynamic and respiratory compromise and/or an altered level of consciousness.

Factors that determine the severity of the clinical condition depend on both the scorpion and the individual who was stung. In the first case, de Roodt et al.[10] found differences between the proteins that make up the venom of *T. trivittatus* from different Argentine provinces. Other authors[11,12] state that clinical manifestations depend on the age of the scorpion, its nutritional status, the amount of poison inoculated, the time of the year, as well as the susceptibility of the victim. Children under 12 years of age and, in particular, children under 2 years of age are more prone to sting-related complications.[13] Consistent with this, age was related to the severity of clinical presentation: younger children were at a greater risk of developing systemic manifestations of scorpionism than older children. Although

TABLE 2. *Comparison of epidemiological and laboratory characteristics between children with moderate and severe scorpionism*

	Parameters	Total (n = 103)	Moderate (n = 80)	Severe (n = 23)	*p* value
Epidemiological data	Age (years)	103	5.8 ± 3.9	4.9 ± 2.8	0.29
	Part of the body stung	103			
	Head and neck		7	5	0.12
	Upper limb and trunk		29	9	
	Lower limb, abdomen, and buttocks		44	9	
	Time elapsed between the sting and the administration of the anti-scorpion serum (min.)	103	60 (60-120)	90 (60-120)	0.81
	Time of day when the sting occurred	103			
	From 12 am to 7:59 am		37	13	0.15[a]
	From 8 am to 3:59 pm		19	7	
	From 4 pm to 11:59 pm		24	3	
	Circumstance under which the sting occurred	94			
	Sleeping		41	12	0.09
	Walking or playing		30	8	
	Putting the shoes on		6	2	
	Having a shower		3	1	
	Length of hospital stay (days)	103	1 (1–1)[b]	3 (2–6)	< 0.001
Lab tests	White blood cells, x 10^3/mL	96	16.9 (15.1–18.8)	22.9 (18.4–27.4)	0.01
	Platelets x 10^3/mL	96	328.6 (305.3–353.5)	371.2 (326.4.1–415.6)	0.33
	Blood glucose, mg/dL	98	200.8 (184.1–219)	253.8 (221.4–286)	0.01
	Potassium, mg/dL	98	3.3 (3.1–3.4)	3.2 (2.9–3.5)	0.72
	Blood urea, mg/dL	91	29.2 (27.3–31.3)	32 (29.1–35)	0.14
	pH	96	7.45 (7.44–7.47)	7.46 (7.43–7.49)	0.5
	pCO_2	96	24.8 (23.2–26.4)	21.2 (18.6–24.1)	0.04
	Bicarbonate	95	16.8 (16–17.6)	14 (13–15.2)	< 0.01
	Amylase, IU/L	75	127.2 (99–160.1)	149 (110.3–196.5)	0.18
	GPT, IU/L	46	15.3 (13.8–17)	18 (14.9–21.59)	0.44
	CPK, IU/L	51	165.9 (141.6–197.4)	197.4 (134.4–264.9)	0.32

aThe Fisher's test was performed between the two groups with the greatest difference (from 12 am to 7:59 am and from 4 pm to 11:59 pm).
bThe interquartile range 25–75 is expressed between parentheses.
GPT: alanine aminotransferase; CPK: creatine phosphokinase.

most reports of severe cases are in children under 12 years of age,[9,14] there are also records of severe compromise even in adolescents.[15] These descriptions refer to severe scorpionism in previously healthy children, without a history of cardiovascular, respiratory, neurological or another type of comorbidity. In adults stung by *T. trivittatus*,[16] pre-existing arterial hypertension was associated with a higher risk for systemic clinical manifestations. In pediatrics, it is not possible to extrapolate such conclusions, given that arterial hypertension is a rare clinical sign, secondary to a renal or endocrinological condition giving rise to it.

The clinical severity of stings also varied depending on the different seasons of the year in which they occurred. Although the number of children stung during the winter was markedly lower, the risk for moderate or severe manifestations increased during this season, as well as during the spring. A hypothesis that explains the heterogeneous behavior of stings among seasons is related to the life cycle of the scorpion: during the fall, the scorpion's activity decreases in order to stock up on crickets or cockroaches and thus, it concentrates venom that will be available for the next attacks, which occur in the following seasons with the greater availability of food.

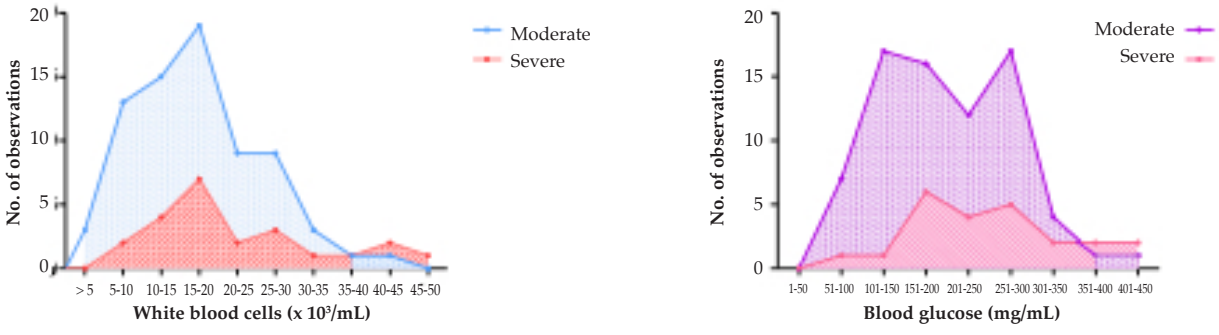
Most of the stings occurred during the night, while children were sleeping or walking barefoot. To prevent these accidents, it is advisable to check and shake out sheets, sneakers, and floor cloths before use. It is also recommended to be highly suspicious of scorpionism when a child suddenly starts crying, feeling pain and/or vomiting at dawn, even in the absence of a specimen.

Seventeen percent of the children from the city of Santa Fe had systemic manifestations versus 35% of those from other towns. This difference may be attributed to children with mild scorpionism who are not transferred to a tertiary care hospital if general symptoms are not present within 6 hours of the sting, as indicated by national standards,[3] rather than to regional differences related to the scorpion or the host.

There are reports that the delay in the administration of an anti-scorpion serum is associated with a worse clinical course.[16,17] Although the delay was longer in children with severe scorpionism than in those with moderate symptoms, this difference did not reach statistical significance. On the other hand, the length of hospital stay was clearly different between both groups: more than 50% of children with moderate scorpionism recovered within 24 hours, while those with severe symptoms stayed at the hospital from 2 to 6 days.

White blood cell count and blood glucose level showed differences between children with moderate symptoms and those with severe scorpionism. Similarly, in some studies that evaluated the severity of scorpionism by *Androctonus crassicauda*[17] and *Leirus quinquestratus*[18] in Turkey and Egypt, respectively, similar results were obtained. Although there are different species of scorpions, they all belong to the family *Buthidae*, and the pathogenic mechanism by which they act is by triggering an autonomic storm and a systemic inflammatory reaction in response to venom inoculation. The cut-off points analyzed for both white blood cell count and blood glucose had a low sensitivity and a high specificity to be able to discriminate among groups. This is because only a small number of children with moderate scorpionism had values above the cut-off point (false positives).

FIGURE 3. *Distribution of white blood cell count and blood glucose level among children with moderate and severe scorpionism*



Severe cases had lower bicarbonate and pCO_2 levels compared to moderate cases, which is to be expected given their different clinical condition.

In this study, it was not possible to obtain information on scorpions. The specimen size is a factor to take into account when the objective assessed is the clinical severity of envenomation following a sting. A classification bias may occur at the time of distinguishing between moderate and severe scorpionism. The definition of severe scorpionism includes an altered level of consciousness, respiratory effort and/or hemodynamic compromise, which are conditioned to a subjective evaluation of the physician defining the severity. The description of signs and symptoms in the medical records of children with severe scorpionism in all cases justified such classification.

CONCLUSIONS

The results of this study show that, in children stung by *Tityus carrilloi n. sp*. in the littoral region of Argentina, younger age as well as winter and spring seasons are associated with a higher risk for systemic envenomation. In addition, a white blood cell count greater than 30 000 mm^3 or a blood glucose level greater than 300 mg/dL was mostly present in cases of severe scorpionism. ■

Acknowledgments

The authors would like to thank all the members of the health care team of Hospital de Niños Dr. Orlando Alassia who participated in the care of patients; María Isabel Donnet, M.D., Juan Carlos Beltramino, M.D., and Diana Fabbro, M.D. for the suggestions made in the manuscript; and Fabiana Molina, M.D., for her support in conducting the study.

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