Arch Argent Pediatr. 2026;e202611112

Clinical and hematological predictors of severity in pediatric patients with *Centruroides* scorpion stings

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ABSTRACT

Introduction. In Mexico, scorpion stings are the leading cause of death from contact with venomous animals among children under 5 years of age. Despite a decline in mortality over the past 20 years, this remains a public health problem. The objective of this study was to describe the correlation between the severity of scorpion sting poisoning and the age, anthropometric profile, and hematological profile of pediatric patients treated in the emergency department.

Population and methods. Descriptive, cross-sectional, analytical study. Variables such as age, sex, bite location, signs and symptoms, weight, height, body mass index, white blood cell count, and platelet count were analyzed, along with their correlation with the severity of poisoning using Spearman's correlation. Differences between severity groups were assessed using the Kruskal-Wallis test, and the strength of association of the independent variables was evaluated using ordinal logistic regression, with a significance level of $p < 0.05$.

Results. A total of 349 patients stung by scorpions of the genus *Centruroides* were analyzed over 10 years. A negative correlation was observed between age, weight, and height and the severity of poisoning ($p = 0.001$); that is, the younger the patient and the lower their weight and height, the greater the severity of poisoning. A positive correlation was also observed between an increase in white blood cell count and severity ($p = 0.001$).

Conclusion. In the multivariate analysis, young age was confirmed as an independent determinant of the severity of poisoning. Leukocytosis is a marker of severe poisoning.

Keywords: *scorpion stings; poisoning; age distribution; pediatrics.*

doi: http://dx.doi.org/10.5546/aap.2026-11112.eng

To cite: Pintado Tovar G, Robledo Aceves M, Barrón Balderas A, Corona Gutiérrez AA, Camarena Pulido EE. Clinical and hematological predictors of severity in pediatric patients with *Centruroides* scorpion stings. *Arch Argent Pediatr.* 2026;e202611112. Online ahead of print 10-SEP-2026.

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Funding*: None.*

Conflict of interest*: None.*

Received*: 4-8-2026*
Accepted*: 6-22-2026*

INTRODUCTION

Scorpion sting poisoning (SSP) is a public health problem in warm regions of Latin America due to the widespread distribution of these arthropods. Tropical and subtropical regions, in particular, are endemic for this condition.[1,2] Mexico is home to 12% of the world's scorpion diversity,[2,3] with approximately 130 species and subspecies, primarily from the family Buthidae, genus *Centruroides*, in the western region of the country.[3-5] This family is considered one of the most venomous to humans.[1] Our hospital's service area is located in this region, where a high incidence of cases is recorded annually.

It takes between four and seven minutes for the injected venom to enter the systemic circulation.[6] It contains scorpamines, low-molecular-weight neurotoxins that activate sodium, potassium, and calcium channels, triggering the release of neurotransmitters at presynaptic terminals, the production of inflammatory mediators, and increased capillary permeability, with a risk of multiple organ failure and death.[1,3-7]

Treatment is based on the fabotherapeutic [$F(ab')_2$], equine immunoglobulin fragment directed against *Centruroides*, which blocks the interaction of scorpion toxins with neuronal calcium channels and prevents toxic symptoms, with greater effectiveness and a lower incidence of adverse effects than whole immunoglobulin.[3,8]

SSP is classified into three categories. Mild toxicity presents with pain, paresthesias, and pruritus at the injection site. Moderate toxicity adds sialorrhea, epiphora, dysphagia, fasciculations, dyspnea, abdominal distension, and priapism. Severe cases also include nystagmus, dysarthria, cyanosis, mydriasis or miosis, seizures, arrhythmias, and multiple organ failure. Treatment includes one vial of $F(ab')_2$ for mild cases, two for moderate cases, and for severe cases, start with two and increase the dose every 60 minutes depending on the patient's response (every 30 minutes if there is no improvement). In pediatric patients under 5 years of age, double the initial dose, given their smaller volume of distribution and higher relative concentration of venom.[6]

Given the above, the objective of this study was to describe the correlation between the severity of SSP and the age, anthropometric profile, and hematological profile of pediatric patients treated in the emergency department.

POPULATION AND METHODS

Design and population

The study was conducted in the pediatric emergency department of a tertiary-care hospital in Jalisco (Mexico) over 10 years. This is a descriptive, cross-sectional, analytical study. The Hospital Civil de Guadalajara Dr. Juan I. Menchaca has a referral toxicology unit for the care of patients with suspected poisoning, staff trained in the diagnosis and treatment of various toxins, as well as antidotes such as $F(ab')_2$ for poisoning from venomous animals.

All pediatric patients with suspected SSP were included. The diagnosis was established primarily based on clinical criteria. Patients in whom laboratory results confirmed organophosphate poisoning (an initial clinical presentation similar to that of SSP) were excluded. Those who did not provide consent to participate were excluded.

The information was collected through medical records and a survey. It included: age, sex, signs and symptoms, time of symptom onset, time of transport to the health facility, use of traditional medicine before care, location of the bite, time of day, and the patient's activity at the time of the incident, as well as identification of the animal via photograph or a specimen brought to the hospital. If the animal was recovered (alive or dead), medical staff performed an initial taxonomic identification to determine its level of danger and forwarded it to the Jalisco Ministry of Health (SSJ, by its Spanish acronym) for identification of genus and species. The season was determined based on the date of admission.

Based on the signs and symptoms, the severity of poisoning was classified as mild, moderate, or severe according to NOM-033,[6] for dosage determination of $F(ab')_2$. All patients underwent blood tests, weight and height measurements, and their body mass index (BMI) was calculated.

Statistical analysis

For qualitative variables, frequency and percentages were calculated. For age, anthropometric measurements, and laboratory data, the minimum, maximum, mean, and standard deviation (SD) were calculated. In the bivariate analysis, the correlation between the severity of poisoning and the independent variables was assessed using Spearman's correlation (rho). Differences between groups were analyzed using the Kruskal-Wallis test. To determine the strength of association, a multivariate analysis was performed using ordinal

logistic regression, adjusted for severity, reporting the regression coefficient, odds ratio (OR), and its 95% confidence interval (95%CI), with a significance level of p <0.05. The analysis was performed using IBM SPSS Statistics™ version 21.0.0 and JASP 0.96™.

Ethical considerations

The research complied with the General Health Law on Health Research of the United Mexican States. It was approved by the Ethics Committee, CONBIOÉTICA-14-CEI-008-20161212, issued on June 1, 2021, with ruling 00033, as well as the principles of the Declaration of Helsinki, as updated in 2024.

RESULTS

During the study period, 462 cases of suspected SSP were treated. Twenty-nine cases were confirmed as organophosphate poisoning, and 84 cases that did not meet the inclusion criteria were excluded, resulting in 349 cases for analysis. Most stings occurred in the spring and summer, frequently in the early morning and at night, which coincides with the scorpions' active hours (*Table 1*). Regarding severity, 62 cases were mild; 163 were moderate; and 124 were severe. The frequency of signs and symptoms by severity is presented in *Table 2*.

For 337 patients, it was their first scorpion sting; for 10, it was their second; and 2 patients had experienced more than four previous stings. All the scorpions were identified as *Centruroides elegans* and *C. infamatus*, species endemic to Jalisco. Eight patients received traditional medicine before seeking treatment at the hospital, consisting of drinking milk alone or combined with garlic; only one person attempted to suck out the poison with his mouth.

Regarding treatment, 134 patients received at least one vial of $F(ab')_2$, with an average of 2.3 vials per patient (SD ± 1.2 vials). Two people required up to 12 vials each. In one case, $F(ab')_2$ was accidentally administered for *Latrodectus* without any adverse effects.

A negative correlation was observed between age, weight, and height, and the severity of SSP. No such correlation was identified for BMI (*Table 3*). The lowest platelet count recorded was 34.6 ×10³/mm³in a patient with acute lymphoblastic leukemia (ALL) undergoing chemotherapy at the time of the sting. No patients died or experienced adverse effects from the $F(ab')_2$.

When analyzing the differences among the three severity categories with respect to age, weight, height, time to treatment initiation, white blood cell count, and platelet count, the same trend was observed as in the correlation analysis (*Figure 1*). Weight and height showed an initial correlation with the severity of SSP but lost statistical significance in the multivariate analysis (*Table 4*).

DISCUSSION

Scorpion stings rank first worldwide among cases of poisoning caused by venomous animals and plants.[4] Countries such as Brazil and Mexico report an incidence of 50 cases per 100 000 inhabitants.[4,9] Over a period of more than five years, 1% of the patients treated at our unit had SSP.[10] Most cases occurred in the spring and summer, predominantly at night, consistent with reports in the literature. Determining factors include the behavior of the scorpion and the host, which are influenced by the climate. Attacks are less frequent at 16 °C and increase above 19 °C.[4] Scorpions live inside or outside homes, under rocks, or in cracks in walls; in warm weather, they begin to reproduce and their nocturnal activity increases.[11-13] In regions such as the Middle East and Africa, the heat causes people to sleep outdoors.[13] In our community, city dwellers do not typically sleep outside their homes. However, they do open windows and avoid using sheets, which increases the likelihood of coming into contact

Table 1. Epidemiological characteristics and bite topography

Characteristic	n = 349 n (%) / n (%)
Gender (male/female)	183 (52.4) / 166 (47.6)
Season (spring/summer/fall/winter)	107 (30.7) / 82 (23.5) / 92 (26.4) / 68 (19.5)
Time of day (morning/afternoon/evening)	52 (14.9) / 57 (16.3) / 240 (68.8)
Location in the house (indoors/outdoors)	313 (89.7) / 36 (10.3)
State of consciousness (asleep/awake)	210 (60.2) / 139 (39.8)
Topography (limbs/head/trunk/unknown)	253 (72.4) / 16 (6.2) / 22 (6.3) / 53 (15.1)

with a scorpion. Most patients reported finding the scorpion among the sheets or seeing it fall from the ceiling or walls.

Toxicity depends on the amount of venom injected, the number of stings, and the host's age, since a lower body mass promotes the distribution of the venom and increases its toxicity. [6,8,12] In our study, no correlation was identified between gravity and BMI, likely because this index reflects nutritional status and the influence of height dilutes the effect of body weight; individuals with different weights may have similar BMIs, which masks their association with gravity. Medeiros et al. report that most people who suffered from SSP were between the ages of 29 and 49; however, mortality was four times higher in children under 9 years of age—that is, in a pediatric population such as that in our study—

Table 2. Clinical characteristics of patients stung by scorpions, by severity

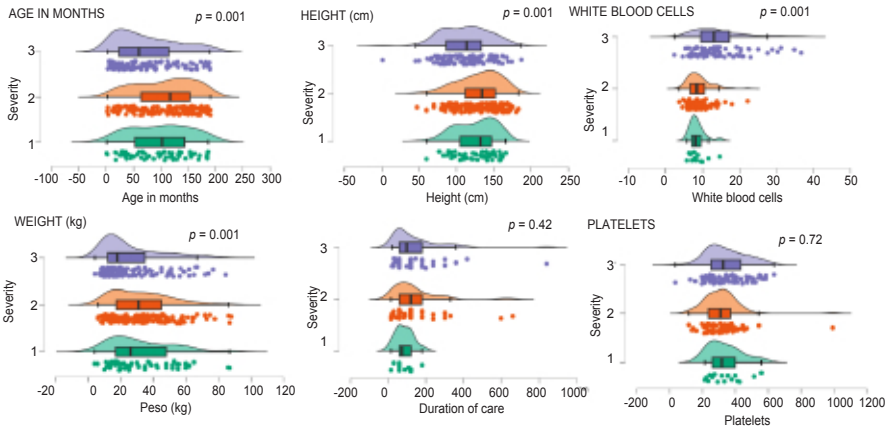
Signs and symptoms n (%)	Mild n = 62 n (%)	Moderate n = 163 n (%)	Severe n = 124 n (%)	Total n = 349 n (%)
Local pain	59 (95.1)	158 (96.9)	102 (82.2)	319 (91.4)
Local paresthesia	23 (37)	58 (35.5)	35 (28.2)	116 (33.2)
Tachycardia	2 (3.2)	27 (16.5)	44 (35.4)	73 (33)
Headache	1 (1.6)	15 (9.2)	9 (7.2)	25 (7.1)
Nasal itching	1 (1.6)	14 (8.5)	3 (2.4)	18 (5.1)
Foreign body in the throat	-	81 (49.6)	35 (28.2)	116 (33.2)
Fasciculations	-	67 (41.1)	82 (66.1)	149 (42.6)
Hypersalivation	-	56 (34.3)	88 (70.9)	144 (41.2)
Dysphagia	-	24 (14.7)	18 (14.5)	42 (12)
Dyspnea	-	17 (10.4)	29 (23.3)	46 (31.1)
Dry mouth	-	12 (7.3)	5 (4)	17 (4.8)
Ocular erythema	-	10 (6.1)	10 (8)	20 (5.7)
Epiphora	-	9 (5.5)	11 (8.8)	20 (5.7)
Priapism	-	6 (3.6)	10 (8)	16 (94.5)
Fever	-	1 (0.6)	23 (18.5)	24 (6.8)
Abdominal distension	-	1 (0.6)	7 (5.6)	8 (2.2)
Nystagmus	-	-	76 (61.2)	76 (21.7)
Dyslalia	-	-	13 (10.4)	13 (3.7)
Cyanosis	-	-	10 (8)	10 (2.8)
Ataxia	-	-	7 (5.6)	7 (2)
Miosis	-	-	7 (5.6)	7 (2)
Photophobia	-	-	5 (4)	5 (1.4)
Bradycardia	-	-	5 (4)	5 (1.4)
Seizures	-	-	4 (3.2)	4 (1.1)
Mydriasis	-	-	4 (3.2)	4 (1.1)
Arrhythmia	-	-	2 (1.6)	2 (0.5)
Fecal incontinence	-	-	1 (0.8)	1 (0.2)

Table 3. Correlation between the severity of scorpion sting poisoning and anthropometric and laboratory characteristics

Characteristics	Minimum	Maximum	Mean (SD)	rho	*p*-value
Age (months)	1	183	122.9 (3.02)	-0.214	0.001
Weight (kg)	3.8	88	30.3 (1.15)	-0.203	0.0001
Height (cm)	0.93	183	122.92 (1.71)	-0.212	0.0001
Body mass index (kg/m^2)	6.61	66.6	20.01 (0.89)	-0.067	0.23
White blood cells (× 10^3/mm^3)	2.36	36.6	11.33 (0.44)	0.426	0.001
Platelets (× 10^3/mm^3)	34.65	994	331.84 (8.98)	0.092	0.23
F(ab')$_2$ application time (min)	15	840	136.9 (12.5)	0.005	0.55

SD: standard deviation, rho: Spearman's correlation coefficient with a statistically significant p*-value <0.05.*

Figure 1. Distribution of variables (age in months, weight, height, body mass index, white blood cell count, and platelet count) according to the severity of scorpion sting poisoning



The data are presented as a scatter plot with box-and-whisker plots (median and interquartile range). Comparisons between groups were performed using the Kruskal-Wallis test, with the corresponding p-value indicated.

Table 4. Multivariate analysis of the association between the independent variables and the severity of clinical presentation

Characteristics	β	*p*	OR	95%CI for β
Age (months)	-0.020	0.008	0.98	-0.34; -0.005
Weight (kg)	0.009	0.42	1	-0.017; 0.06
Height (cm)	-0.010	0.34	0.99	-0.031; 0.011
Body mass index (kg/m^2)	-0.020	0.13	0.98	-0.046; 0.006
F(ab')$_2$ application time (min)	0.002	0.12	1	-0.001; 0.005

Results obtained using ordinal logistic regression adjusted for the independent variables and the severity of poisoning, with a statistically significant p*-value <0.05.*
β: estimated coefficients; OR: odds ratio; 95%CI: 95% confidence interval for the estimated coefficient.

due to greater distribution of the toxin in a smaller body mass.[9] Vazirianzadeh et al. note that children are more prone to severe cardiac, respiratory, and neurological complications, and identified hematuria as an indicator of kidney damage in moderate-to-severe cases,[14,15] a finding not observed in our population, likely because it involved a different species (*Hemiscorpius lepturus*). In our study, the correlation analysis confirmed a negative association between age and somatometry and the severity of SSP: the younger the age and the lower the weight and height, the greater the degree of intoxication. However, in the ordinal logistic regression, somatometry lost statistical significance, which may be explained by the high correlation among age, weight, and height (multicollinearity); when these variables are included simultaneously in the model, they cause instability in the coefficients. This constitutes a limitation of the study, and it is suggested that nested models be compared in future research.

Regarding laboratory parameters, a positive correlation was identified between increases in blood leukocytes and platelets and the severity of SSP, attributable to two mechanisms. The first is the adrenergic response to stress: the venom triggers a massive release of catecholamines, which induces leukocyte demargination and the release of young platelets from the bone marrow.

The second mechanism involves the activation of proinflammatory cytokines by scorpamines, leading to the progression of the local response to a severe systemic one.[6,16] Leukocytosis was statistically significant both in terms of correlation and when comparing groups by severity. However, although a platelet increase would be physiologically expected due to the adrenergic response, this increase was not consistent enough in the sample to reach statistical significance; therefore, platelets were not a reliable predictor of severity. Furthermore, unlike

what was reported by Petricevich, no progression toward thrombocytopenia or disseminated intravascular coagulation was observed, which could be explained by the early interruption of the inflammatory cascade through timely treatment with $F(ab´)_2$.[16]

Several studies report that *Centruroides* venom increases platelet aggregation in animal models, although the molecular basis is not yet known.[17] Caglar et al. (2015) reported platelet counts of 540 × 10^3/mm^3 in severe cases and 391 ×10^3/mm^3 in mild and moderate cases, identifying the platelet increase as a predictor of severity (p = 0.02) in bites from *Andronoctus crassicauda* and *Leiurus quinquestriatus*.[18] Robledo *et al.* (2024) also reported a positive Pearson correlation between platelet count and the severity of SSP, using a smaller sample size.[19] Like these authors, we found a positive correlation with a slight increase in platelet count as severity increased in a different species (*Centruroides*). Konca *et al.* (2014) compared platelet counts between stung children and healthy controls, finding higher levels in the former that did not reach statistical significance, attributed to the small sample size and the use of corticosteroids or anti-inflammatory drugs.[17] In our study, platelet count was not a predictor of severity, possibly due to the inclusion of patients with low baseline values and the absence of a control group. The positive correlation is consistent, although not statistically significant. In contrast, leukocytosis is confirmed as a marker of severity in SSP, in accordance with the literature.

CONCLUSION

Age is the only parameter that remains significantly associated with the severity of the SSP in the multivariate analysis; weight, height, and BMI no longer show this association. Regarding laboratory parameters, leukocytosis shows a positive and statistically significant correlation with severity, making it a useful marker in clinical evaluation. In contrast, platelet count, although showing a positive trend, did not reach statistical significance in *Centruroides* SSP, and the characteristics of the sample did not allow it to be established as an independent predictor.

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