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Pediatric electrocardiograph abnormalities following *Centruroides limpidus tecomanus* scorpion envenomation

P. Diaz[a], G. Chowell[b,*], G. Ceja[c], T.C. D'Auria[b], R.C. Lloyd[b], C. Castillo-Chavez[d]

[a]*Instituto Mexicano del Seguro Social (IMSS), Colima, Col. 28010, Mexico*
[b]*Biological Statistics and Computational Biology, Cornell University, 432 Warren Hall, Ithaca, NY 14853, USA*
[c]*Facultad de Medicina, Universidad de Colima, Colonia Las Viboras, Colima, Col. 28045, Mexico*
[d]*Department of Mathematics and Statistics, Arizona State University, P.O. Box 871804, Tempe, AZ 85287-1804, USA*

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Abstract

Scorpionism is an endemic public health problem in Mexico [Hoffmann, C.C., 1936. La distribucion geografica de los alacranes peligrosos en la Republica Mexicana. Bol. Inst. Hygiene Mex. 2, 321; Hoffmann, C.C., Nieto, D.R., 1939. Segunda contribucion al conocimiento de los alacranes mexicanos. Anal. Inst. Biol. 10, 83–92; Mazzoti, L., Bravo-Becherelle, M.A., 1963. Scorpionism in the Mexican Republic. In: Keegan, H.L., McFarlane, W.V. (Eds.), Venomous and Poissonous Animals and Noxious Plants of the Pacific Area. Pergamon Press, London, pp. 119–131; Monroy-Velasco, J., 1961. Alacranes venenosos de Mexico. Rev. Mex. Cien. Med. Biol., Mex. 1, 1–23; Diaz-Najera, A., 1975. Listas y datos de distribucion geografica de los alacranes de Mexico. Rev. Inv. Salud. Publica. (Mex.) 35, 1; Velasco-Castrejon, O., Lara-Aguilera, R., Alatorre, H., 1976. Aspectos epidemiologicos y clinicos de la picadura de alacran en una area hiperendemica. Rev. Inv. Salud Publica. (Mex.) 36, 93–103; Dehesa-Davila, M., Possani, L.D., 1994. Scorpionism and serotherapy in Mexico. Toxicon 32 (9), 1015–1018]. In this prospective study, we assess cardiovascular disorders in children via electrocardiographic (ECG) recordings following envenomation by scorpion species *Centruroides limpidus tecomanus* found in the state of Colima, Mexico. We analyzed 113 cases between the ages of 5 and 14 years. Among the most frequent symptoms presented included local pain (99.1%) and paresthesia (75.2%), pruritus (36.3%), sialorrhoea (35.4%), and nystagmus (24.8%). Cardiovascular disorders were observed in 39.8% of cases, 71% of which were rhythm abnormalities. We find a significant association between the frequency of ECG alterations and age, whereby 8–9-year-old children are more likely to experience ECG alterations when compared with other tested age groups.

Keywords: Scorpion envenoming; *Centruroides limpidus tecomanus*; Cardiovascular alterations

1. Introduction

Scorpion envenoming is a particularly devastating problem in Mexico (Hoffmann, 1936; Hoffmann and Nieto, 1939; Mazzoti and Bravo-Becherelle, 1963; Monroy-Velasco, 1961; Vega and Lia-J, 1966; Diaz-Najera, 1975; Velasco-Castrejon et al., 1976; Dehesa-Davila and Possani, 1994) where the world's highest mortality rate of up to 1000 deaths in one year has been reported (Bush and Charles, 2003). In Mexico, approximately 134 species or sub-species of scorpion have been identified, 30 of which belong to the genus *Centruroides*; eight are known to be

* Corresponding author. Fax: +1 607 255 4698.
E-mail address: gc82@cornell.edu (G. Chowell).

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dangerous to humans (Dehesa-Davila and Possani, 1994). The venomous species, which are found on eleven Mexican states bordering the pacific ocean, include *Centruroides elegans*, *C. infamatus infamatus*, *C. limpidus limpidus*, *C. limpidus tecomanus*, *C. noxius*, *C. pallidiceps*, *C. sculpturatus* and *C. suffusus suffusus* (Dehesa-Davila and Possani, 1994; Zarate-Aguilar and Maraboto-Martinez, 1997; Chavez Haro, 1998). It is estimated that there were approximately 200,000 cases of scorpion stings in Mexico during 1976 alone (Dehesa-Davila and Possani, 1994). Most studies have focused on the clinical and epidemiological aspects of scorpion stings. However, the venom of several scorpion species can trigger cardiovascular disturbances (Gueron and Ovsyscher, 1987; Bawaskar, 1991; Gueron et al., 1992; Freire-Maia et al., 1994; Bucaretchi et al., 1995). In this prospective study, we assess clinical and cardiovascular disorders in children via electrocardiographic (ECG) recordings following envenoming by scorpion species *C. limpidus tecomanus* found in the state of Colima, Mexico.

2. Materials and methods

An observational study was conducted from January to December of 1999 in the General Hospital of Zone No. 1 of the Mexican Institute of Public Health (IMSS) in the city of Colima, state of Colima, Mexico. This city is located on the pacific coast at an altitude of 500 m, has a tropical climate, and a population of approximately 110,977 people (INEGI, 1995). Only children who arrived at the emergency room within 1 h after the sting were used in this study. The candidates were not treated with scorpion antivenom serum, atropine, digoxin, or beta-blockers prior to data recording. Furthermore, the candidates had no prior history of cardiac problems and were well developed and nourished at the time of this study. To evaluate the children's nutritional state, we used weight/size and size/age indices according to the parameters established by the National Center for Health Statistics in the United States (NCHS) and incorporated in the official Mexican Norm for the control of nutrition, growth and development of children and adolescents (NOM-008 SSA 2-1993).

If antivenom serum was needed, an ECG was conducted prior to administration. A second ECG was conducted prior to the patient being discharged from the emergency room. A third ECG was carried out four weeks following emergency room discharge on patients who exhibited ECG abnormalities during either of the first two tests. Since the effects of scorpion venom only persist for up to 30 days (Gajre and Dammas, 1998), patients who demonstrated an abnormal ECG four weeks later were eliminated from the study; these abnormalities most likely indicate a preexisting condition unrelated to envenoming.

Patients were assigned to one of three clinical states (mild, moderate and severe) based on a clinical evaluation, enabling us to examine for a possible correlation between severity of presenting symptoms and the frequency of abnormal ECGs:

(a) *Mild:* patients with symptoms limited to localized pain and/or paresthesia.
(b) *Moderate:* patients with symptoms including any one of the following—sialorrhoea, general paresthesia, nasal and/or pharyngeal pruritus and restlessness.
(c) *Severe:* patients with globus hystericus, nystagmus, vomiting, abdominal distension, episthotonos, muscle ataxia, grand mal seizure, dysarthria, and blurry vision.

We express our results as the mean $\pm$ the standard deviation (SD) of the data. The statistical analysis was carried out using the chi-squared test of independence. For the purposes of analysis, a normal electrocardiogram shows normal sinus rhythm with normal conduction indices, ST and T wave morphology. All other electrocardiographic results are considered abnormal.

3. Results

One hundred and thirteen individuals (57 males and 56 females) were included in this analysis. The average age of males was 9.1 ± 3.2 (SD) with a mode of 5 years. For females, the average age was 9.8 ± 3.2 with a mode of 14 years. The ratio male/female was 1.01:1. The mean time elapsed from sting to admission to the emergency room was 0.52 h (SD 0.32 h). The symptoms presented by the patients in this study are shown in Fig. 1. Priapism was not observed. However, hyperhidrosis in the site of the sting was observed in some cases but it was not registered.

Fifty-seven patients (50.4%) were classified as mild cases, 26 (23%) as moderate, and 30 (26.5%) as severe 45 (39.8%) patients demonstrated abnormal ECGs. However, we did not find a significant association between the frequency of abnormal ECGs and the severity of symptoms presented (Table 1; $P = 0.406$). Table 2 shows the distribution of cases with abnormal and normal ECGs by age groups. The average age of the patients with ECG alterations was 9.0 ± 2.9 years with a mode of 9 years. Twenty-two (38.5%) males presented abnormal ECGs compared to 23 (41%) for females ($P = 0.788$), indicating no evidence of an association between ECG abnormality and gender.

We found a significant association between age group and the frequency of abnormal ECGs observed following scorpion envenoming (P-value $= 0.008$). The standardized deviations for each age group indicated that only 8–9-year-old children had a greater frequency of abnormal ECGs than would be expected if there were no correlation between age and abnormal ECGs (Agresti, 1996). The ECG alterations (Table 3) that were observed included 32 (71%) patients with cardiac dysrhythmias, 15 (33.2%)

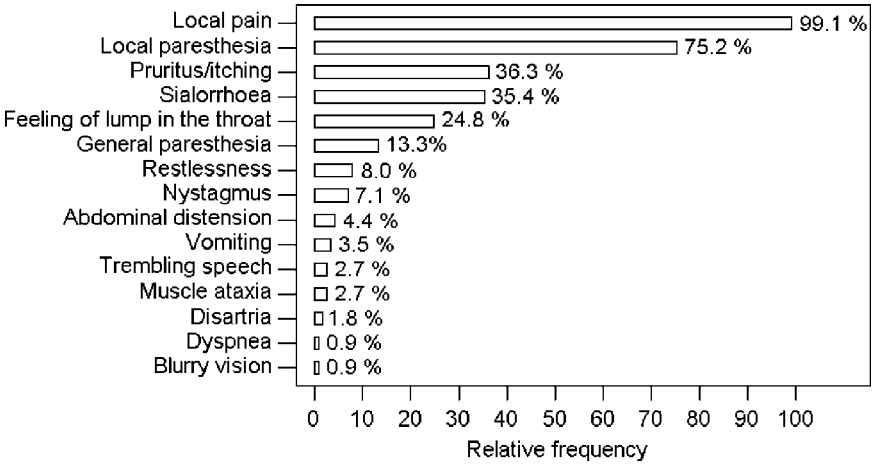

Fig. 1. Relative frequency of symptoms developed by patients after scorpion sting.

patients with intraventricular conduction disturbances, and four (8.8%) patients with ventricular repolarization disturbances.

4. Discussion

There are a number of reports on the clinical and epidemiological aspects of the scorpion sting in Mexico (Hoffmann, 1936; Hoffmann and Nieto, 1939; Mazzoti and Bravo-Becherelle, 1963; Monroy-Velasco, 1961; Vega and Lia-J, 1966; Velasco-Castrejon et al., 1976; Martinez-Medina et al., 1983; Dehesa-Davila, 1989; Lagunas-Flores and Villegas-Arrison, 1989; Gonzalez Romero et al., 1991; Aldana-Gonzalez and Aldana Gonzalez, 1992; Dehesa-Davila and Possani, 1994; Zarate-Aguilar and Maraboto-Martinez, 1997; Hernandez-Lomeli et al., 1994). Velasco- Castrejon (1976) analyzed the clinical aspects of 100 cases of scorpion stings of which the majority were due to scorpions from the species *C. limpidus tecomanus*. However, their analysis does not make a distinction among the different scorpion species that were involved, namely *C. limpidus tecomanus*, *C. limpidus limpidus*, *C. elegans elegans*, and *Vejovis mejicanus*.

We observed similar incidence in the number of males and females being stung by scorpion. This observation agrees with other studies (Velasco-Castrejon et al., 1976; Martinez Medina et al., 1983; Lagunas Flores and Villegas Arrison, 1989; Aldana Gonzalez and Aldana Gonzalez, 1992; Hernandez-Lomeli et al., 1994; Dehesa-Davila and Possani, 1994; Carbajal Ugarte et al., 1999).

We did not find an association between gender and ECG alterations following envenomation. This agrees with the results of Gonzalez Romero et al. (1991). On the other hand, our results indicate that only 8–9-year-old children have a greater number of abnormal ECGs than we would expect if there were no association between age and abnormal ECGs following envenomation. In fact, De Roodt et al. (2003) reported a similar association where cases in the age group from 0 to 10 years presented a higher frequency of cardiovascular and circulatory symptoms compared to those from 11 years or older following envenomation by the scorpion *Tityus trivittatus* in Argentina. It would be interesting to look closer at their data and determine which age group or groups within the 0–10 year-olds are significantly more susceptible to cardiovascular abnormalities following envenomation. More data will be needed (only 16 observations for the 8–9 age group) before we can draw any conclusions about a potential association between the severity of symptoms

Table 1
Distribution by clinical state of the cases with abnormal ECG

Clinical state	Abnormal ECG	Normal ECG	Total
Mild	21	36	57
Moderate	9	17	26
Severe	15	15	30
Total	45	68	113

Table 2
Distribution of cases with abnormal and normal ECGs by age groups

Age group (years)	Abnormal ECG	Normal ECG	Total
5	8	12	20
6–7	6	14	20
8–9	13	3	16
10–11	8	11	19
12–13	6	13	19
14	4	15	19
Total	45	68	113

Table 3
Frequency of electrocardiographic alterations following scorpion sting

Disturbance found in ECG	Observed alteration	Relative frequency (%)
Cardiac rhythm disturbance	Sinus tachycardia	13.3
	Atrial tachycardia	48.8
	Supraventricular tachycardia not sustained	4.5
	Bradycardia	2.2
	Sinus arrhythmia	2.2
Disturbances of ventricular repolarisation	Hyper acute T	6.6
	Inversion of the T wave	2.2
Disturbances of the intraventricular conduction	Incomplete blockage of the right branch of the bundle of His	22.2
	Blockage of the right branch of the bundle of His	8.8
	Increase of the ventricular automatism	2.2

presented and the frequency of abnormal ECGs patients in the 8–9 age group (Supplementary materials).

Centruroides polyvalent antivenom, produced by BIOCLON Institute (2004) (4), was administered to children 5 years of age and younger and those in moderate and severe states (67 out of the 113 children). None of the children died. The antivenom is enzymatically digested and lyophilized. One ampoule neutralizes 150 LD_{50} in mice tested intraperitoneally (8).

In our study, ECG alterations appeared with higher frequency in patients with severe symptoms. However, no association between the clinical state and the appearance of ECG alterations was found to be statistically significant.

Since our study only examined healthy children who were well nourished and developed, it would be important to study this phenomenon in children with nutritional problems. Optimal emergency room treatment for envenomated children could depend on the nutritional state of the affected child.

The frequency of ECG alterations in children reported in the literature varies between 10.9% (Mazzei et al., 1997) and 64% (Bucaretchi et al., 1995) of scorpion stings. We observed electrocardiographic alterations in 39.8% of the children. Gonzalez Romero et al. (1991) reports a frequency of 40.7% in the number of cases with electrocardiographic alterations in 722 scorpion stings due to the scorpion species *Centruroides suffussus suffussus*. This scorpion species is less toxic and also smaller than scorpion species *C. limpidus tecomanus* (Hoffmann and Nieto, 1939). The number of ECG alterations observed in both scorpion species is similar despite their difference in toxicity.

A study of 38,068 *Centruroides infamatus infamatus* scorpion sting cases in the city of Leon, Guanajuato, Mexico reported 53% of cases with systemic manifestations that included pulmonary edema, arterial hypertension or hypotension, tachycardia or bradycardia, heart failure, nausea, vomiting and abdominal distension, among others (Dehesa-Davila, 1989). Another study was carried out with 64 patients stung by scorpion species *Tityus zulianus* in Merida, Venezuela between 1989 and 1992 (Mazzei et al., 1997). In this study, 57.8% of cases presented systemic manifestations including cardiac arrhythmias, pulmonary edema and intractable cardiogenic shock.

This study may have several unique clinical impacts. First, since 8–9 year-olds have a higher probability of ECG abnormalities following envenomation, funding can be targeted towards preventative care within this age group. Parents can be educated to better protect and reduce exposure of this age group to environments or conditions where this scorpion is prevalent. Second, this study may assist medical professionals in assigning clinical priorities to envenomated patients in a triage setting. While younger age groups may have been assigned clinical priority in the past, this study indicates that 8–9 year-olds may need priority care due to their higher susceptibility to cardiac disturbances. Finally, this study may open the door to further research that aims to investigate the biochemical mechanisms behind the observed age association. To the best of our knowledge, this is the first report aiming to establish the electrocardiographic alterations following envenomation by the scorpion *C. limpidus tecomanus* that inhabits the state of Colima, Mexico.

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