Journal of Clinical Toxicology
ISSN: 2161-0495

Cavari et al., J Clin Toxicol 2015, 5:4
DOI: 10.4172/2161-0495.1000263

Research Article Open Access

# The Intensive Care Management of Children with Scorpion Envenomation

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**Received date:** May 27, 2015; **Accepted date:** Aug 21, 2015; **Published date:** Aug 31, 2015



## Abstract

**Objective:** Scorpion envenomation is a serious health problem worldwide, and a common health hazard in the southern region of Israel. Cardiac dysfunction is the leading cause of morbidity and death. Early bedside echocardiography showed to identify all victims with cardiac involvement. We looked for our management of stung children using clinical evaluation, serum troponin, and early echocardiography in cases of moderate and severe envenomation.

**Materials and methods:** Retrospective cohort study of children admitted to the Pediatric Intensive Care Unit after scorpion sting during 5 years, 2008-2013. Review of electronic medical records for demography, clinical and laboratory data, especially echocardiography and serum troponin T level, treatment and outcome.

**Results:** Total number of envenomated children was 185. Age ranged between 1 month and 18 years, 53 were below 3 years of age. Main clinical presentation included decrease level of consciousness (22%) and respiratory failure (15%). Echocardiography on arrival was performed on 117 (63%) children and was abnormal in 29, of whom 25 received inotropic support and 10 required mechanical ventilation. Serum troponin T was measured on arrival in 170 (92%) children and was elevated in 29, of whom 15 (52%) had abnormal echocardiogram; Comparing troponin results to echocardiography; it had a low sensitivity (52%) in identifying cardiac dysfunction. 17 infants below 3 years of age required ventilation for (central) hypopnea and apneic episodes. All children below age 3 had normal echocardiogram. All 185 children survived the envenomation and discharged without sequel.

**Conclusion:** Early echocardiography should be preferably performed in all scorpion envenomated children. Early serum troponin misses sensitivity for cardiac dysfunction. In our patient population cardiac involvements was not present in children under age 3. Respiratory failure is mainly secondary to central CNS effect in young infants and cardiac dysfunction in older children.

**Keywords:** Sting; Cardiac dysfunction; Echocardiography; Pediatric; Troponin; Respiratory failure

## Introduction

Scorpion sting is a common medical hazard in certain parts of the world. It is estimated that the annual number of scorpion stings worldwide exceeds 1.2 million patients, leading to morbidity and mortality [1]. Most victims of scorpion sting suffer only from localized pain. Systemic intoxication when occur may include stimulation or depression of the central nervous system (CNS), stimulation of the autonomic nervous system (sympathetic and/or parasympathetic), and activation of the inflammatory cascade [1-3]. Thus, irritability and restlessness, hypothermia or hyperthermia, tachycardia or bradycardia, hypertension, excessive sweating, salivation and vomiting are common symptoms. CNS, cardiac and respiratory failures are less common but may lead to death [1,2,4-9]. Children experience more severe envenomation and their mortality rate is higher [1,2,10]. The most dreadful harm of intoxication are heart failure, tachyarrhythmia, cardiogenic pulmonary edema and shock. Clinical signs of heart failure may start within minutes after the sting or may develop hours later [4,7,11-13].

Previous prospective study from our institution showed that left ventricular hypokinesia, decrease fractional shortening and left ventricle ejection fraction (LVEF) detected on echocardiography (echo) of victims shortly after the sting, provided early hemodynamic support. Normal echo study upon hospital arrival excluded the possibility of subsequent heart failure [14].

In comparison to the previous study where echo was part of the protocol and had to be done within three hours of admission, echo examination in our current study was done at the discretion of the attending pediatric intensive care unit (PICU) physician who decided to call upon a senior cardiologist. In this retrospective study we sought to evaluate our everyday practice, and to assess again the need of echo examination in all cases of scorpion envenomation. In addition, we wanted to evaluate again the relevance of early blood troponin measurement upon arrival.

We also sought to confirm our previous observation that hemodynamic changes are uncommon in young children and that respiratory failure at this age is mainly related to bradypnea and apneic episodes that are apparently secondary to CNS effect of the venom [4,6,14]

In view of our excellent clinical results in the management of scorpion envenomation in children, we briefly report our main approach to management and therapy.

The most common and dangerous scorpion in the southern Negev desert of Israel is the "yellow scorpion" *Leiurus quinquestriatus hebraeus*". About 30-50 scorpion envenomated children, are admitted to the PICU annually.

## Materials and Methods

This retrospective study involved all children admitted to the PICU of the Soroka University Medical Center with signs and symptoms of general intoxication after scorpion sting. Children arrived to the emergency department (ED) with local manifestation alone (class 1) [15] were not admitted to the PICU and excluded from the study. Data was collected from the medical records of all envenomated children during 5 year period between July 2008 and June 2013.

Our medical center is the only hospital in the Negev southern region of Israel, serving population of about 600,000; among them 180,000 are Bedouin Arabs, native inhabitants of the Negev desert. The study was approved by the hospital's Ethics Committee.

The electronic medical records (Metavision, iMDSoft, Needham Heights, MA) of children stung by scorpion were reviewed for their demographic and clinical data. Laboratory results were reviewed for serum troponin T level taken within 15 minutes of ED admission, during the first intravenous access placement-as a marker of cardiac injury. When repeated, second troponin sample was taken on the second admission day. Echo was performed within two hours of arrival and evaluated by a senior pediatric cardiologist. It was repeated on the next day of admission according to clinical judgment.

Bedside echocardiography evaluation was done as previously described [14]. Left chamber dimensions measurements at end systole and end diastole. Left ventricular systolic function was assessed by means of ejection fraction (EF) and factional shortening (FS) and calculated in the standard manner. Abnormal systolic function was defined as FS below 28% and/or EF below 54% and/or borderline-normal FS and EF with poorly contracting wall motion (Hypokinesia).

In this study we concentrated mainly on the more seriously envenomated children. Therefore, we focused our data collection to the level of consciousness, the present or absent of respiratory distress, cardiac failure and the need for inotropic support, mechanical ventilation, length of stay in the PICU and hospital. Mechanical ventilation was initiated in cases of respiratory failure due to bradypnea/apneic episodes and or tachypnea and dyspnea in cases of cardiac failure. Continuous intravenous dobutamine was initiated in children with abnormal echo. Dopamine, milrinone and adrenaline were used if cardiac dysfunction aggravated despite dobutamine therapy. Antivenom serotherapy was administered according to the decision of the attending physician.

We described qualitative variables by mean and standard deviations (SD) and qualitative variables by absolute numbers and percent. We compared between continuous and categorical variables echo groups using one-way Anova and chi-square, respectively. Differences with P value under 0.05 were accepted as statistically significant.

## Results

185 children with signs and symptoms of general envenomation after scorpion sting were admitted to the PICU and included in our study. Demographic and major clinical characteristics upon PICU admission are presented in Table 1. Age distribution ranged between 1 month and 18 years. 53 (29%) of the children were three years old or younger. Bedouin origin and male gender were more prone to be stung. Three major life threatening indications for PICU admission were recognized: Decrease level of consciousness in 40 (22%) patients. Respiratory failure secondary to hypopnea or apneic episodes in 17 (9%) children and respiratory instability with cardiac dysfunction in 10 (5.4%) children. All these 27 children required mechanical ventilation. 25 (14%) children were given inotropic support for hypokinesia and decrease fractional shortening documented on early echocardiography.

Patients age 3 years' old and younger showed different characteristics than older envenomated children. Decrease level of consciousness was more common in younger children (36%) in comparison to older children (16%) ($p<0.008$). 25% of younger children were mechanically ventilated in comparison to 11% in the older children group ($p<0.02$). All ventilated children in the younger group had respiratory failure due to apnea or hypopnea and none had any signs of cardiac failure.

117 out of 185 (63%) patients had an echo study shortly after arrival. All 68 patients that did not have an echo examination were mildly symptomatic and their PICU and hospital length of stay was significantly shorter than patients who had an echo examination ($p<0.001$) (Table 2). Therefore we assumed that their echo examination would have been normal. 29/185 (16%) patients had notable pathological findings in their echo examination. In most of the children with an echo examination, troponin was measured (107/117). Compering to echo results, troponin level upon arrival had low sensitivity in identifying cardiac involvement (sensitivity 52%, specificity 88%, PPV 63% and NPV 83%). Moreover, among the 14 children with abnormal echo and normal troponin level, 10 children were in need for inotropic support and 5 of them required mechanical ventilation. Ultimately, all patients' echo returned to normal on follow up examination.

Repeated troponin taken 24 hours post envenomation, had higher sensitivity than troponin on admission for cardiac injury. In 46 patients which a second troponin sample was taken (in correlation with clinical signs and the echo results), the second troponin level was raised in all patients with abnormal echo. Compared to their matched admission troponin level, these repeated troponin levels had higher sensitivity and lower specificity (first troponin sensitivity 57% and specificity 83% in comparison to second troponin sensitivity 96% and specificity 65%).

Regarding mechanical ventilation, comparison between the 17 patients with normal echo (group 1) to the 10 patients with abnormal echo (group 2), showed that these groups vary significantly. Group 2 patients were older, had higher troponin level, longer ventilation time and longer PICU and hospital length of stay (Table 3).

Antivenom was given to 11 patients, 3 with normal echo and 8 with abnormal echo. Inotrope support was started in all cases with dobutamine. It was given at a dose of 5-10 mcg/kg/min to 26 patients, all but one, with abnormal echo. In addition, dopamine drip 5-25 mcg/kg/min was given to 5 patients, and adrenaline drip 0.1-1.3 mcg/kg/min to 3 patients. Milrinon drip was added to 6 patients.

Mean hospital length of stay for all children was 42.6 ± 50.6 hours. All survived and discharged home with no sequel. PICU and hospital length of stay were significantly longer in patients with abnormal echo in comparison to children with normal echo or those in whom echo was not performed. The group of patients that had no echo examination had the shortest length of stay (Table 3).

## Discussion

Scorpion envenomation is a common medical hazard in many areas of the world and an important cause of morbidity and mortality, especially among children [1,2,9,10].

Heart failure and cardiogenic shock are known to be the most hazardous complications, [1,2,4,7-13,16] and as such need to be recognized and treated as soon as possible. Symptoms of hemodynamic compromise may occur shortly after the sting or delayed for several hours, with the appearance or worsening of tachycardia, tachypnea, dyspnea, hypotension, and signs of reduced peripheral perfusion [4,7,8,11-13] Therefore admission in a PICU is of paramount importance as well as finding ways to early recognize those patients with cardiac dysfunction. Bahloul et al. [9], reported analysis of 685 cases of scorpion envenomation from Tunisie, and found that children are in high risk of life threatening cardiac depression, which initially may be missed and remained unnoticed until patient deterioration. Delay in diagnosis of high risk children, may adversely affect their outcome. Previous studies showed that early bedside echo has 100% sensitivity and specificity in identifying myocardial dysfunction in cases of scorpion envenomation [14,17,18]. This allow early initiation of targeted hemodynamic monitoring and support. As suggested by Sagarad et al. [17,18] apparently not all patients with decrease left ventricular ejection fraction (LVEF) on early echo required inotropic support. Those with only mild LVEF decrease might be closely clinically and echographicly observed. This should be done however in a PICU environment as showed in Sagarad study where 10% of the patients with initial, mild LVEF decrease who were sent to the ward, required later on, inotropic support for hemodynamic deterioration. In our current study only 4 of the 29 patients who had left ventricular dysfunction on echo were treated without inotropic support. All were closely observed in the PICU and did well. In all other 25 children dobutamine drip was started. It was changed to dopamine in 5 and to adrenaline drip in 3 due to severe hemodynamic deterioration. 6 children received in addition milrinon drip. Dobutamine has been shown to have a quick therapeutic effect in these cases, enhancing LVEF, cardiac output and oxygen delivery to the tissues [7,19]. Our practice of treatment initiation with dobutamine is based both on published literature and our past 15 years experience in treating these children, while our unpublished experience with initial adrenaline treatment seemed to cause ventricular arrhythmias. In agreement with our previous study, serum troponin was not helpful in detecting early injury as 10 of the 14 patients that had normal troponin despite pathological echo required inotropic support and 5 of them were ventilated as well. These findings are also in agreement with Cupo and Hering [20] who found low correlation between troponin and echo findings upon arrival. Meki et al. [21] and Sagarad et al. [17,18] however found 100% sensitivity and specificity between troponin level and echo results. This differences can be explained by the different time gap between the sting and troponin measurement in the different studies. In Sagarad studies all patients were initially admitted to a local hospital and then referred to the hospital where the study was held. In Meki's study mean arrival time after the sting was 15.9 h, whereas in our center most patients arrive within 3 h of sting [14].

Children that present to the ED within few hours after the sting with no clear clinical symptoms of cardiac dysfunction might show troponin level that does not correlate well with the degree of the cardiac depression seen on echo. Whereas echo is a mirror image of the envenomation affect, troponin is a biochemical marker that its build up is time sensitive. Second day troponin, in more severe envenomated children, had higher sensitivity than admission troponin, and when in doubt a repeat troponin test may be helpful [14,17,18,21].

Our current and previous studies strongly suggest that in any case of severe envenomation an early echo should be performed. This can be easily done in institutions providing 24/7 in-house cardiology services. Fulfilling this task in other institutions, would enclose educational approach and training of non-cardiologist physician in ED and PICU to identify hypokinesia and decrease contractility on echo. Children with mild symptoms of intoxication and normal echo, might be sent from the ED to the pediatric ward [20-22].

The natural history of envenomation varies by age: hemodynamic changes are uncommon in babies and infants younger than 2 years old [4,7,8,12,14,23,24]. In our current study none of the 53 children below age 3 years had cardiac dysfunction. This explain also the differences among the 2 groups of ventilated children: group 1 consisted of young infants with normal heart function, who presented in respiratory failure with hypopnea and apneic episodes presumably related to the toxic effect of the venom on the CNS, causing severe encephalopathy [4,6]; group 2-older children with cardiac dysfunction, where respiratory failure was characterized by tachypnea and dyspnea as part of the failing heart. Patients from group 1 had no pulmonary pathology, had a much shorter course of ventilation; they recovered earlier and had shorter PICU and hospital length of stay.

Only 11 patients in our study received anti-venom sero-therapy. This modality of therapy in scorpion envenomation is controversial [1,2,13,25-27] and therefore we allow the attending physician to decide whether to use it or not.

This retrospective observational study suffers from all limitations of retrospective studies. It is however a recording of our everyday practice based on implementation of conclusions drowns from a previous structured prospective study [14] and therefore we believe it may be valuable for clinicians dealing with scorpion envenomation.

Using the parameters above, such as age, type of failure (cardiac vs. respiratory), clinical presentation and echocardiography allow the clinician to anticipate who is prone to complications and who isn't and to treat accordingly.

Mortality rate among scorpion envenomated children in our institution decreased with time from 11% in the 60's (20$^{th}$ century) [16], to 2% in the 90's [13] and 0% in last decade (323 children). We reflect this achievement to the practice described above.

## Conclusion

Early echocardiography should be preferably performed in all scorpion envenomated children. Early serum troponin misses sensitivity for cardiac dysfunction. Cardiac involvements are not common in children under age 3.

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