



Original Contribution

A clinical score predicting the need for hospitalization in scorpion envenomation

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Received 29 July 2006; accepted 21 August 2006

Abstract

Objective: Predicting complications is a clinical challenge in the assessment of victims of scorpion envenomation (SE). We sought to develop a clinical score to predict need for hospitalization after scorpion sting.

Methods: We prospectively collected data in patients attending the emergency department after SE in derivation (n = 868) and validation groups (n = 435). A score was derived from a multiple regression analyses using clinical variables as dependent variables and hospitalization as independent variable.

Results: Discrimination power of the constructed score was good (area under the receiver operating characteristic curve, 0.85 and 0.83 in derivation and validation group, respectively). Goodness-of-fit tests indicated that the score performed well in the derivation and the validation groups ($P = .88$ and $P = .67$ respectively). The score has a good sensitivity and negative predictive value at cutoff value of 2.

Conclusion: Our clinical score could be used for efficient hospital admission decision in patient's victims of SE.

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1. Introduction

Of the 40000 scorpion-envenomed patients that are reported each year in Tunisia, 90% occur in rural areas, affecting predominantly young victims. The epidemiologic picture is quite similar in many other developing countries where mortality ratio remains unacceptably high (250-300/100000) [1-6]. The leading causes of complications and

deaths include pulmonary edema and congestive heart failure. Most of these complications and deaths are preventable. The main preventable factors include inability to early recognize the severity and delay in referring victims to specific health care facilities. Hospital-related preventable factors in endemic areas include inadequate skills and lack of intensive care units. Indeed, delay in seeking emergent treatment contributes to most of rural deaths. In endemic Tunisian areas, most patients live more than 50 km from the nearest facility offering intensive care. Approximately more than 2 hours are needed to reach the district hospital.

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Tunisian health authorities began to recognize the importance of the problem and the need for emergent intervention. They understood that primary health care system at the district and subdistrict levels need strengthening to provide adequate medical services. During the past few years, projects were designed to upgrade some district hospitals, and several intensive care units (ICUs) were created. Although there seems to have been a slight drop in scorpion envenomation (SE) mortality, the number of needless death remains high. Failure to early identify high-risk patients at the first-line health care was considered as one of the potential causes of this failure. Although there is no consensus on the criteria for hospital admission, several recommendations suggest that all patients should be observed during up to 4 hours in the first-line care facility before transfer to the nearest community-based hospital [7,8]. However, for low-risk patients, the time required for observation in the emergency department (ED) is often useless. Likewise, for high-risk patients, this observation period will be a waste of time and could adversely affect outcome because their transfer from rural setting to the nearest hospital will likely be unsafe and too late. Clinicians dealing with SE need more objective guidelines for the assessment of their patients to guide their decision making in a way that minimizes both complications and unnecessary health care costs. Prediction rules using scoring systems designed to estimate the probability of complication and the need for hospital admission may provide the key to achieving this goal [9]. In this report, we developed and validated a clinical score based on initial ED presentation that would allow one to determine if hospital admission and therapeutic intervention is needed.

2. Patients and methods

The study was prospectively conducted in the ED of Tozeur Hospital between June 1995 and December 1997 (first period) and between January 1998 and September 1999 (second period). This community-based hospital is the only one that covers all southwest Tunisia, which is a rural and endemic area for SE. Yearly, almost 20 000 hospital visits due to SE are reported (*Androctonus australis* Hector). We prospectively included all patients attending the ED.

2.1. Inclusion criteria

Consecutive patients older than 10 years who came to the ED were included in the study if they have a documented history of scorpion sting, with the scorpion being seen or captured by the patient or bystander.

2.2. Exclusion criteria

Patients were excluded from the study if there was a clinical evidence of a serious life-threatening symptoms requiring prompt admission to ICU. Life-threatening symptoms are defined by the presence of (1) hypotension

(systolic blood pressure <90 mm Hg or a sustained decrease in systolic blood pressure >40 mm Hg) or clinical signs of peripheral choc; (2) respiratory failure defined by the presence of tachypnea (respiratory rate >30 breaths per minute), accessory muscle use, and requirement of oxygen therapy or mechanical ventilation; (3) neurologic distress defined as a Glasgow Coma Scale score of 13 or lower. We also excluded patients with serious comorbidity. Elderly patients were not excluded.

2.3. Data collection

All the data were prospectively collected by treating physicians. Patients received information concerning the study and were asked to give informed consent for participation. Baseline data were recorded on standard form, including the following: age, sex, comorbidity, scorpion color, time between scorpion sting and arrival to the hospital, standard vital signs, and treatment received before reaching the ED. Any case without complete data sheet was excluded. Patients were provided symptomatic treatment and re-evaluated at hourly intervals for up to 4 hours. At the end of the ED observation period, patients were discharged home or hospitalized according to standard accepted criteria: patients totally asymptomatic or with only local symptoms were discharged home. According to the Tunisian Ministry of Health recommendations, those patients with systemic symptoms or who showed serious worsening of their clinical condition were admitted in the ward or the ICU.

2.4. Construction of the score

The score was constructed using data of patients enrolled during the first study period between June 1995 and December 1997 (derivation group). All data analyses were performed with the Statistical Package for the Social Sciences (SPSS 10.0, SPSS, Chicago, Ill). Association of categorical and dependent variables with the hospitalization decision was assessed with χ^2 test, and the significance of continuous variables was assessed with Student *t* and Wilcoxon rank sum tests. Variables were eligible for entry into a multiple logistic regression model if they were significantly associated with hospitalization decision at a *P* value of less than .1. Variables associated with *P* < .05 were retained in the final model. To develop a practical scoring system, all continuous variables were dichotomized. Cutoff points were chosen to make optimal use of the information, with the condition that the cutoff values demarcate a clearly abnormal state and, if possible agree, with cutoff values used in the literature. No dichotomized covariates were entered into the model unless the continuous analogue had a significant independent predictive effect. This strategy was used to ensure that the selection of predictive factors for the model would be independent of the choice of the various cutoff points. The coefficients obtained from the logistic regression were multiplied by a scaling factor to produce a scoring system that required the

Table 1 Patients' characteristics in the derivation and validation groups

	Derivation group (n= 868)	Validation group (n= 435)	P
Mean age (y) (SD)	34.8 (17.9)	35.9 (17.9)	.28
Men (%)	530 (61.1)	277 (63.7)	.36
Recurrence of scorpion sting (n [%])	97 (11.8)	49 (11.3)	.72
Time delay to ED arrival (min) (median [range])	40.3 (15-112)	42.1 (21-135)	.45
Localization of sting (n [%])			
Arms	407 (47)	217 (50)	.43
Legs	377 (43)	187 (43)	.95
Others	84 (10)	31 (7)	
Vital signs (mean [SD])			
Blood pressure (mm Hg)			
Systolic	124 (25)	123 (25)	.57
Diastolic	65 (16)	64 (16)	.49
Heart rate (beats per min)	85 (13)	86 (14)	.21
Respiratory rate (breaths per min)	21 (4)	22 (4)	.48
Temperature >38°C (n [%])	113 (13.0)	61 (14.0)	.72
Priapism (n [%])	15 (1.7)	8 (1.8)	.88
Agitation (n [%])	16 (1.8)	10 (2.3)	.58
Vomiting (n [%])	32 (3.7)	20 (4.6)	.32
Abdominal distension (n [%])	17 (1.9)	4 (0.9)	.24
Diarrhea (n [%])	8 (0.9)	4 (0.9)	1.00
Local pain (n [%])	798 (91.9)	404 (92.6)	0.73
Treatment received before arrival to ED			
Scorpion antivenom (n [%])	469 (53.6)	213 (48.6)	.10
Corticosteroids (n [%])	125 (14.4)	54 (12.4)	.10
Length of ED stay (hours) (SD)	4.7 (1.5)	4.9 (1.5)	.63
Hospital admission (n [%])	121 (13.9)	61 (14.0)	.73
Length of hospital stay (d) (SD)	1.1 (1.4)	1.5 (1.3)	.09

addition of integer values. The ability of the score to classify patients (discrimination) was assessed by the area under the receiver operating characteristic curve (ROC) for dichotomous outcomes [10]. To evaluate model calibration, we performed Hosmer-Lemeshow goodness-of-fit test comparing observed with expected hospitalization rate [11]. Low χ^2 values and high corresponding *P* values for the Hosmer-Lemeshow statistic indicate that the data can be adequately fit to a logistic function.

2.5. Validation of the score

The validation group included patients who met the same entry criteria and enrolled between January 1998 and

September 1999. The value of the score for every patient in this group was calculated using the same equation of the score described in the development group. Predictive performance of the score was analyzed using the same indices (calibration and discrimination).

The study was approved by our hospital's institutional review board. It was designed, conducted, and analyzed independently of any sponsor.

3. Results

Overall, 1399 patients presented to the ED after a scorpion sting during the 2 periods of the study. Of these, 96 patients (59 in the derivation group and 37 in the validation group) failed to satisfy entry criteria and were excluded. The reason

Table 2 Univariate analysis comparing hospitalized and non hospitalized patients

	Hospitalized n = 121	Non hospitalized n = 747	P value
Mean age (y) (SD)	35.6 ± 19	35.0 ± 18	NS
Men (%)	77 (63.6)	453 (60.6)	NS
Recurrence of scorpion sting (n [%])	9 (7.4)	88 (11.8)	NS
Time delay to ED arrival (min) (median [range])	81.3 ± 87	36.2 ± 61	<.001
Localization of sting (n [%])			
Legs	70 (57.8)	307 (41.1)	<.001
Arms	14 (36.4)	363 (48.6)	<.001
Head and Trunk	7 (5.8)	77 (10.3)	<.001
Vital signs (mean [SD])			
Blood pressure (mm Hg)			
Systolic	144 ± 32	122 ± 23	<.001
Diastolic	74 ± 20	68 ± 15	<.001
Heart rate (beats per minute)	93 ± 27	84 ± 12	<.001
Respiratory rate (breaths per min)	24 ± 6	21 ± 3	NS
Temperature >38°C (n [%])	24 (20.5)	89 (12)	<.001
Priapism (n [%])	12 (10.5)	3 (0.4)	.000
Vomiting (n [%])	22 (18.1)	10 (1.3)	<.001
Abdominal distension (n [%])	9 (7.4)	8 (1.1)	<.001
Diarrhea (n [%])	4 (3.3)	4 (0.5)	NS
Local pain (n [%])	114 (94.2)	684 (91.6)	NS
Treatment received before arrival to ED			
Scorpion antivenom (n [%])	96 (79.3)	373 (49.9)	<0.001
Corticosteroids (n [%])	67 (55.3)	58 (7.8)	<0.001

NS, nonsignificant.

Table 3 Multivariable analysis of variables associated to hospital admission and related coefficients for score calculation

Variable	OR	95% CI	Coefficient
Priapism	150.59	54.20-257.12	+3
Vomiting	15.82	5.50-25.49	+2
Systolic blood pressure >160 mm Hg	13.38	5.75-21.12	+2
Corticosteroids administration before arrival to ED	10.06	3.80-19.16	+2
Time delay to ED arrival >30 min	3.71	1.53-9.01	+1
Temperature >38°C	3.66	1.75-7.63	+1
Heart rate >100 beats per minute	3.35	1.38-8.13	+1

OR, odds ratio.

of the exclusion included immediate clinical severity (pulmonary edema [n = 12], acute circulatory failure [n = 2], altered consciousness [n = 1]), age less than 10 years (n = 40), serious comorbidity (n = 9) and missing covariate data (n = 32). Thus, 1303 victims of scorpion sting satisfied all entry criteria and comprised the development (n = 868) and the validation population (n = 435).

3.1. Description of the derivation and validation groups

Approximately two thirds of the overall population were women, and most of them had no comorbid illness, whereas more than 10% were stung by scorpion for the second time. One hundred eighty-two patients (13.9%) were admitted to the hospital after a 4-hour evaluation period in the ED. Of these, 35 patients (19.2%) were admitted to ICU. The derivation group and the validation group were similar with respect to age and sex distribution, previous health status, and clinical features (Table 1).

3.2. Correlates of hospitalization decision in the Derivation group

One hundred twenty-one patients (13.9%) were hospitalized in the derivation group. Results of univariate analysis comparing baseline characteristics of hospitalized and nonhospitalized patients are shown in Table 2. Multivariable analysis revealed the following 7 independent predictors of hospitalization with their correspondent coefficients (Table 3): treatment with corticosteroids received before reaching ED, time delay between scorpion sting and the first presentation in the ED of 30 minutes or longer, vomiting, priapism, temperature above 38°C, heart rate above 100 beats per minute, and systolic arterial pressure above 160 mm Hg. For each patient, risk score was calculated by adding the score coefficients associated to each significant clinical variable derived from multivariate analysis. The score ranged from 0 to 12.

3.3. Assessment of the score performance

The mean score in the derivation group was 4.1 ± 1.5 in hospitalized patients, as compared to 0.9 ± 0.4 in nonhospitalized patients ($P < .001$). The area under the ROC curve of our score was 0.85 (95% confidence interval [CI], 0.78-0.92) (Fig. 1A). The goodness-of-fit test showed a good agreement between observed and expected hospitalization rate with a Hosmer Lemeshow statistic of 0.64 ($P = .88$). Using a cutoff value of 2, our score identified 108 patients among 121 (sensitivity, 89.2%) of those who

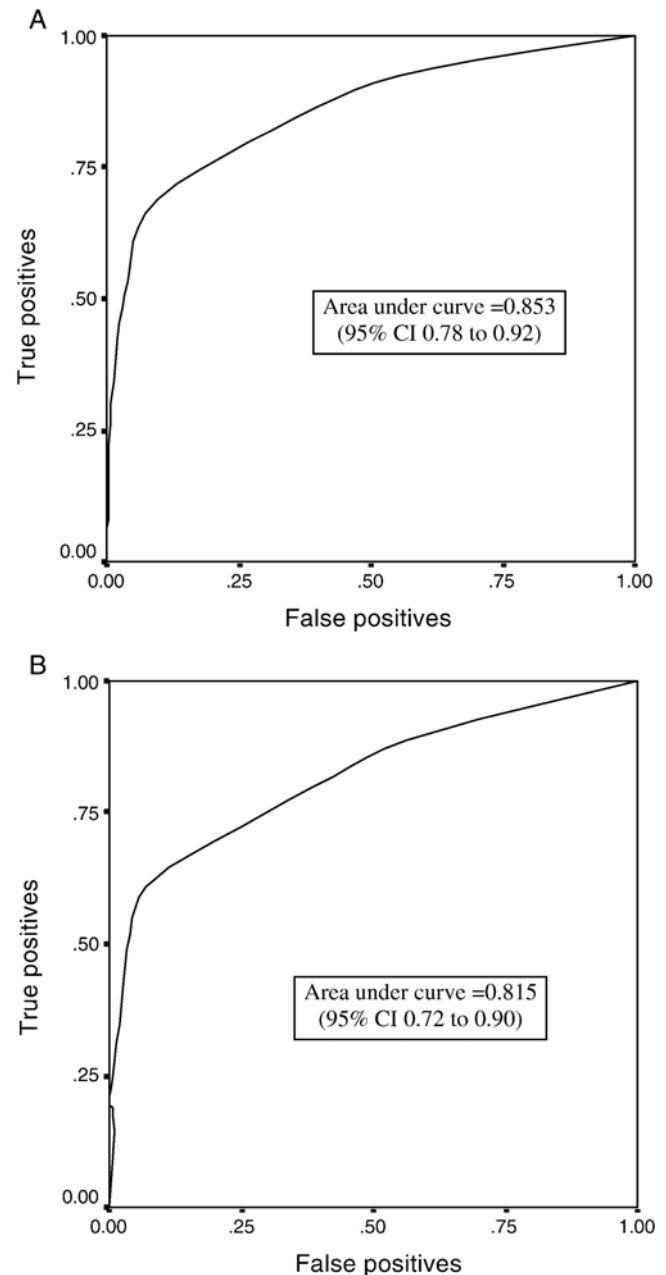


Fig. 1 A, Receiver operating characteristic curve in the derivation group. B, Receiver operating characteristic curve in the validation group.

Table 4 Observed and predicted hospitalization rate using a cutoff value 2

	Hospitalized (n)	Nonhospitalized (n)	Total (n)
Derivation group ^a			
Score ≥ 2	108	309	417
Score < 2	13	438	451
Total	121	747	868
Validation group			
Score ≥ 2	51	153	204
Score < 2	10	221	231
Total	61	374	435

^a Sensitivity, 89.2%; specificity, 41.4%; positive predictive value, 25.9%; negative predictive value, 97.1%.

needed hospitalization and 438 patients among 451 (negative predictive value, 97.1%) of those did not require hospitalization (Table 4).

3.4. Validation of the score

The mean score was 3.8 ± 1.5 in the hospitalized group, as compared to 1.0 ± 0.3 in the nonhospitalized group ($P < .001$). The area under the ROC curve was 0,83 (95% CI, 0,72-0,90) (Fig. 1B), and Hosmer Lemeshow statistic was 1.52 ($P = .67$).

4. Discussion

Our results indicate that standard clinical characteristics routinely obtained during the initial medical evaluation of patients who are victims of SE can be used to construct a simple classification system aiming to aid early decision about hospitalization. The developed score includes variables that can be easily obtained when a patient with scorpion sting presents to the ED. Moreover, the score can be calculated without the aid of a computer and could be assessed by either medical or paramedical staff. Our score discriminate well between patients who needed hospitalization and those who did not. A cutoff value of 2 provided a good sensitivity and negative predictive value, indicating that it is safe to discharge patients at the first clinical evaluation when the score is less than 2.

The most common important predictor factor for hospital admission found in our study was priapism. Nineteen patients (82.6%) presenting with priapism at the initial physical examination have been eventually hospitalized. In those for whom hospitalization was not decided (4 patients), priapism was the only symptom associated with local signs. Vomiting was an important predictor of hospitalization, a finding that is in agreement with previous reports associating vomiting with the severity of SE [12]. Vomiting was usually related to acute pancreatitis, an explanation that is not widely accepted [12,13]. Other significant variables included in our score were those related to catecholamine

discharge induced by scorpion venom [14-17]. Previous studies have clearly demonstrated the importance of this hormonal activation in SE and correlation of hypertension to cardiovascular dysfunction. Corticosteroids were commonly administered in SE despite the lack of evidence of benefit. They may merely be a marker for more serious envenomation. However, the single randomized controlled trial performed by our group addressing this issue provided negative results [18]. That corticosteroids administration is independently associated with hospitalization decision suggests that these drugs are not only ineffective in SE but are likely harmful. Our study found that the time delay between scorpion sting and ED arrival is an independent predictor of hospitalization. The explanation is not obvious but delay may relate to location and specific scorpion characteristics [19]. In agreement with previous studies, fever was frequently observed in SE. In animal models, it was demonstrated that fever could interfere with toxicokinetic properties of scorpion venom by decreasing its half life elimination and its volume distribution and, hence, increasing its blood levels [20]. In addition, hyperthermia has been associated to reduction in survival time and electrocardiographic disorders in animals [20].

Our model was designed to be independent of biologic markers because these data may not be available in rural health care facilities. This design allows for broader use because many victims of scorpion sting do not undergo biologic assessment during their initial assessment.

Our study has several limitations. First, we modeled the score on the process rather on the outcome of SE; thus, it identifies which patients may need hospitalization, rather than identifying those at risk for complication and death. The assumption is that every patient admitted needed admission and that every patient discharged did not need admission. Because this outcome is the basis of examining how well our score performed, we checked that no patient who was discharged from the ED actually was admitted. In addition, most of patients who were admitted needed active observation and treatment. Second, because the data used in our modeling were obtained from one center only, the results may not be applicable to other hospital settings. Of note, the toxicity, variation, and duration of symptoms may depend on the scorpion, the features of the sting, the features of the victim, and treatment. Despite these limitations, we should highlight that our study represents one of the largest databases on SE and provide the unique opportunity to study the natural history of this injury during the first hours in human. Moreover, unlike some previous risk classification systems [21], the present score is based on objective clinical criteria.

In conclusion, one of the most important challenges for clinicians dealing with SE is to assess accurately and rapidly the need for hospital referral. They need objective and readily available risk scheme to assess accurately and early the need for hospital transfer or discharge. Our score is a simple screening tool including 7 important clinical risk

factors of hospitalization with excellent calibration and discrimination. It can serve as a useful aid for early triage of patients with SE. If validated in a large independent cohort, this score could be used to optimize patient management.

Acknowledgments

The authors thank Dr Khadija Beloulid, MD, for her support in reviewing the data.

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