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Predictive factors for acute renal failure in crush injuries in the Sichuan earthquake

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ABSTRACT

Introduction: The Sichuan earthquake caused a large number of crush injuries and many of them developed acute renal failure (ARF). A retrospective study was performed on victims with crush injuries of West China Hospital to investigate the predictive factors for acute renal failure (ARF) in crush injuries.
Patients and methods: Medical records of injured victims treated in West China Hospital within the first week after the Sichuan earthquake were retrospectively reviewed and 101 patients with crush injury were enrolled in the study. We divided them into an ARF group and a non-ARF group. The clinical data of included patients were extracted and analysed.
Results: Patients with ARF accounted for 42% of the included population. Patients younger than 20 made up the biggest age category (45%), and the entrapped time under the debris (22 [IQR 3.5–38] h) was longer than previous reports. In univariate analysis, male gender, multiple crush injuries, medical comorbidities, surgical interventions and infections were more frequent in patients with ARF than in those without ARF. Mean arterial pressure was higher in the ARF group. Besides, the risk of ARF was increased by creatine kinase >14,494.5 IU/L most significantly, followed by time under the rubble >4 h, aspartate transaminase >453.5 IU/L, albumin <27.15 g/L and white blood cell $>11.8 \times 10^9$/L. In multivariate analysis, male gender, time under the rubble, multiple crush injuries, surgical interventions, infections and creatine kinase level were independently associated with ARF in crush injuries.
Conclusions: The entrapped time under the debris, multiple crush injuries, male gender, infections, and creatine kinase level are predictive factors for ARF in crush injuries.

Introduction

Wenchuan, located in Sichuan Province in southwest China, was struck by a catastrophic earthquake on May 12, 2008, at 14:28 local time. The disaster registered 8.0 on the Richter scale with a depth of 19 km. According to the official statistics, 69,227 deaths and 374,643 injured were reported, and 17,923 were listed as missing up to September 18, 2008.

Earthquakes are estimated to cause crush injuries in 3–20% of victims.[15] Crush injuries occur when a body part is subjected to a high force or pressure. As a result of muscular compression, myocytes are damaged, followed by the process of rhabdomyolysis, and then systemic organ dysfunction may occur, which is called crush syndrome. Acute renal failure (ARF) is a major component of crush syndrome and has a high mortality.[1–3,20] Identification of predictive factors of ARF in patients with crush injuries is of great significance.

The pathogenesis of renal failure in crush syndrome is multifactorial. When the victim is extricated from the sustained compression, perfusion of the traumatised extremity is restored and large amounts of fluid penetrate the injured muscles, causing circulatory shock and intravascular volume depletion, resulting in prerenal ARF. In addition, myoglobin, urate, and phosphate released by muscle cells causes renal damage by various mechanisms, involving direct renal cytotoxicity, renal vasoconstriction, and renal tubular obstruction.[3,22,23]

More than 2700 patients injured in the disaster were treated in West China Hospital, a comprehensive teaching and researching hospital for adults closest to the severely affected area in the earthquake by July 23, 2008. Among these, 1856 were hospitalised.[27] In this study, we retrospectively reviewed the medical records of patients with crush injuries hospitalised in West China Hospital, with the aim of identifying predictive factors for ARF in crush injuries.

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Patients and methods

Subjects and data collection

We retrospectively reviewed the medical records of the patients hospitalised in West China Hospital within the first week after the disaster and included patients with crush injury according to the following criteria[1,5]: (1) patients were injured due to prolonged, sustained compression on the body; and (2) the affected portion appeared tense and edematous with compromised vascular circulation or neurological disturbances in a physical examination on admission. In addition, some patients with severe crush injuries had been treated before admission to West China Hospital and it was difficult to obtain their pre-hospital medical records. To ensure comprehensive inclusion, we included the patients who had received amputation or fasciotomy before admission. Exclusion criteria included: (1) patients with muscular swelling caused by coexisting conditions other than crush injury, such as bone fractures and iatrogenic factors; (2) patients with other comorbidities that may complicate the study (i.e. chronic kidney diseases); (3) patients who had no information of the potential predictive factors before the onset of ARF documented were also excluded so that a temporal relationship between these factors and the risk of developing ARF can be clarified.

In the study, ARF was defined as at least one of the following: increase in serum creatinine level to above 2 mg/dL, a serum potassium level greater than 6 mmol/L, or oliguria (urine output <400 mL/day).[7,24] Based on this definition, the participants were divided into an ARF group and a non-ARF group. The potential predictive factors considered included demographic characteristics, characteristics of the injuries, surgical interventions, vital signs, laboratory data and associated complications or other comorbid conditions. Medical records of these patients before the onset of ARF were extracted and analysed.

Statistical analysis

Statistical analysis was performed by SPSS (version 13.0). In univariate analysis, descriptive statistics for clinical and laboratory data are presented as median and interquartile range. For continuous data, *Student's t-test* was applied when data showed normal distribution; otherwise, a *Mann–Whitney U-test* was used. In addition, the laboratory parameters with statistical significance in univariate analysis were also calculated by *Receiver Operator Characteristic* (*ROC*) *curves* to identify a cut-off value. *Pearson* χ^2 *tests* or *Fisher's exact tests* (when necessary) were used to compare the categorical variables. Multivariate analysis was performed by *logistic regression* in order to identify the factors independently associated with ARF. In all tests, a *P* value of 0.05 or less was considered statistically significance.

Results

Epidemiology of ARF and demographic characteristics in patients with crush injuries

After the Sichuan earthquake, 2728 patients were transported to West China Hospital and 1856 were hospitalised for further

Table 1
Characteristics of the 101 patients with crush injury in the Sichuan earthquake in West China Hospital[a].

	ARF group ($n=42$)	Non-ARF group ($n=59$)	*P* value
Age (years)	25 (16.50–46.5)	24 (12.95–39.25)	0.130
Gender (male/female)	27/15	21/38	**0.004**
Time under the rubble (h)	22.5 (8–41.75)	12 (0.5–30)	**0.010**
Anatomic parts of body crushed			
Combined crush injury	21 (50%)	15 (25%)	**0.001**
Upper extremities	15 (36%)	15 (25)	0.265
Lower extremities	33 (79%)	42 (71%)	0.265
Trunk	7 (17%)	10 (17%)	0.970
Pelvic region	9 (21%)	6 (10%)	0.117
Surgical interventions			
Overall surgical intervention[b]	20 (48%)	12 (20%)	**0.009**
Fasciotomy before admission	10 (10%)	7 (6%)	0.114
Amputation before admission	11 (26%)	6 (10%)	**0.034**
Infections			
Overall infections	29 (69%)	18 (31%)	< **0.001**
Infections of wounds	23 (55%)	17 (29%)	**0.009**
Systemic and organ infections[c]	17 (40%)	6 (10%)	**0.006**
Comorbidities			
Medical comorbidities[d]	11 (26%)	4 (7%)	**0.007**
Surgical complications[e]	22 (52%)	34 (58%)	0.601
Temperature (°C)	36.95 (36.5–37.2)	37 (36.6–37.5)	0.141
Heart rate (bpm)	92.5 (82–107.75)	90 (82–109)	0.640
Mean arterial pressure (mmHg)	90 (83.42–97.42)	83.33 (75–92)	**0.015**
Haemoglobin (g/L)	108.5 (76–146.5)	103 (77–121)	0.159
White blood cell ($\times 10^9$/L)	14.72 (11.15–20.63)	10 (7.92–14.80)	**0.004**
Platelet ($\times 10^9$/L)	115 (77.5–160)	131 (95–188)	0.136
Albumin (g/L)	23.75 (20.5–31.3)	31.6 (26.5–36.5)	<**0.001**
Creatine kinase (IU/L)	36,069 (17,361–79,716)	4378 (1336–13,884)	<**0.001**
Aspartate transaminase (IU/L)	707.5 (399.25–1490)	135 (55–536)	<**0.001**

The bold values are 5 represent the values with statistical significance (P value of 0.05 or less; as mentioned in Methods Part).
[a] Continuous values are expressed as median (IQR); categorical data are expressed as the number of patients (percentage).
[b] One patient in ARF group and one patient in non-ARF group received both fasciotomy and amputation before admission.
[c] Systematic and organ infections are listed in detail in Table 2.
[d] Medical comorbidities are described in Table 3.
[e] Surgical complications included injuries and subsequent complications caused by trauma other than crush injuries, such as vertebral fractures, traumatic pneumothora and pleural effusion, craniocerebral trauma.