Transfusion and Apheresis Science 45 (2011) 257–260

Contents lists available at SciVerse ScienceDirect

Transfusion and Apheresis Science

journal homepage: www.elsevier.com/locate/transci

Continuous renal replacement therapy and blood transfusions in treating patients with crush syndrome: 8 Case studies from the Wenchuan earthquake

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ARTICLE INFO

Keywords:
Crush syndrome
Acute renal failure
Blood transfusion
Continuous renal replacement therapy

ABSTRACT

Objective: We analyzed the efficacy of continuous renal replacement therapy (CRRT) combined with blood transfusion for patients with crush syndrome from an earthquake.
Methods: Eight patients with crush syndrome were included. CRRT were performed in six of eight patients with crush syndrome, and transfusion was performed in all eight patients. Routine blood tests, urea nitrogen, creatinine, blood coagulation function, electrolyte levels, and serum myoglobin were determined and analyzed.
Results: Two patients regained their health completely, four patients required amputation but recovered well, and two patients died. The total amount of red blood cells transfused in the eight cases was 521 U (mean volume = 68.25 U). CRRT was performed 164 times in six patients (mean 27.33 times per person). The routine blood test results and coagulation and renal function parameters improved obviously ($P < 0.05$) in the six surviving patients.
Conclusions: Sufficient blood transfusion and early dialysis treatment effectively improved the conditions of patients with crush syndrome.

1. Introduction

Crush injuries are commonly observed in victims trapped under fallen masonry in earthquakes. Serious morbidity and even mortality may occur if a crushed victim does not receive medical care until after extrication by 0rescue personnel. Renal failure, shock and disseminated intravascular coagulation (DIC) may be the most serious complications of crush injuries. Therefore, continuous renal replacement therapy (CRRT) and blood transfusion are of great importance and may be widely performed in treating patients with crush syndrome. In the Wenchuan earthquake, a total of 1095 earthquake casualties were admitted into Chengdu military general hospital from May 12th to June 30th, 2008. Of these 1095 casualties, 8 had crush syndrome complicated by acute renal failure, accounting for 0.73% of the total casualties. Blood transfusion was performed in all eight patients, and continuous renal replacement therapy was performed in six patients. Here, we summarize the clinical condition, treatment and outcome of these eight patients in detail.

2. Materials and methods

2.1. General information

In this study, eight patients diagnosed with crush syndrome were included—four males and four females, ranging from 20 to 45 years old (mean 35 years old). They were trapped in collapsed structures for 10–152 h after the earthquake. The diagnostic criteria for crush syndrome were based on Gonzalez et al. [1]. Briefly, compression lasts for longer than 1 h, and the compressed limbs become

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doi:10.1016/j.transci.2011.10.020

tense and edematous, with local circulation involved. The following laboratory values are indicative of crush syndrome: peak creatine kinase over 4000 IU/L, oliguria (urine output less than 400 mL/24 h), elevated blood urea nitrogen (over 40 mg/dL), serum creatinine over 2 mg/dL and potassium over 6 mg/dL.

2.2. Continuous renal replacement therapy

Because of excessive serum myoglobin and poor renal function, CRRT were performed in six of eight patients with crush syndrome. Continuous venovenous hemofiltration (CVVH) was performed via a double lumen cannula inserted into the femoral vein using a bedside hemofiltration apparatus (AQUARIUS, Baxter, US). The blood flow rate was initially 200–250 ml/min. The 2% trisodium citrate solution (citrate 70 mmol/L, sodium 210 mmol/L) consisted of 1500 mL of 5% dextrose and 1500 mL of 4% citrate. The dialyzate flow was 5–6 L/h. The dialyzers were routinely changed at 48 h.

Serum and postfilter ionized calcium levels were measured 1 h after initiation of CRRT and every 6 h thereafter. Arterial blood gases were monitored. The nursing staff was instructed to call for assistance for serum pH <7.20 or >7.45, bicarbonate <15 or >35 mmol/L, or systemic ionized calcium <0.9 or >1.3 mmol/L. When the systemic ionized calcium was <0.9 mmol/L, the calcium infusion was increased by 20 ml/h, and the level was rechecked in 1 h. When the systemic ionized calcium was >1.3 mmol/L, the calcium infusion was decreased by 10 ml/h increments until a therapeutic level was obtained. Any changes to the fluid removal rate, replacement fluid rate, or dialyzate flow rate resulted in reciprocal adjustments to ensure a constant effluent rate of 35 ml/kg per h. Each time, CRRT was continuously performed for 12–24 h. For these six patients, CRRT was performed a total of 164 times (27.33 times per person).

2.3. Clinical transfusion

According to the transfusion indications, red blood cells, fresh frozen plasma and apheresis platelets were transfused to all eight patients with crush syndrome. A total of 30–176 U of erythrocyte suspension (mean volume = 68.25 U) and 2500–26740 mL of plasma (mean volume = 12386.25 mL) was given to these eight patients.

2.4. Laboratory examination

Hemoglobin (HGB), hematocrit (HCT), urea nitrogen (BUN), creatinine (CREA), platelet count (PLT), prothrombin time (PT), activation partial thrombokinase time (APTT), fibrinogen (FIB), myoglobin (Mb) and serum potassium (K^+) were determined every 1 or 2 days. The serum myoglobin was quantitatively determined using the Access Immunoassay System (Beckman Coulter, MN, USA). Technically, it is a two-site immunoenzymatic (“sandwich”) assay. A sample is added to a reaction vessel with mouse monoclonal anti-myoglobinalkaline phosphatase conjugate, mouse monoclonal anti-myoglobinbiotin conjugate, and paramagnetic particles coated with goat anti-biotin.

2.5. Statistical analysis

A one-sample Kolmogorov–Smirnov test indicated that the 10 indices were all normally distributed. The descriptive statistics are reported as mean ± SD. By using the point 1 week after the termination of transfusion or CRRT as the boundary, we can divide the whole study into two periods, an early period and a late period. A comparison of the 10 indices between the early and late periods of the study was performed. The paired *t*-test was adopted, and $P < 0.05$ was considered statistically significant. All statistical analyses were performed using SPSS version 16.0 software (SPSS Inc., Chicago, IL, USA).

3. Results

3.1. CRRT and blood transfusion for patients with crush syndrome (Table 1)

The amount of red blood cells transfused in the eight cases was 521 U in total (mean volume = 68.25 U). The largest amount of red blood cells transfused to a single patient was 176 U, the smallest was 30 U, and the largest amount transfused to a single patient in 1 day was 22 U. The amount of fresh frozen plasma transfused was 99,090 ml in total (mean volume = 12386.25 ml). The largest amount of plasma transfused to a single patient was 26740 ml, while the smallest was 5610 ml (mean = 11700 ml). Apheresis platelet transfusion was performed in five patients. The total amount of platelets transfused was 229 U (mean volume = 45.8 U). The largest amount of platelets transfused to a single patient was 90 U, and the smallest was 10 U. CRRT was performed 164 times in six patients (mean 27.33 times per person). For a single patient, CRRT was performed 37 times at most and 14 times at least.

3.2. Clinical outcomes

Six patients underwent amputation surgery (eight limbs were amputated), including two cases of unilateral lower limb amputation, two case of bilateral lower limb amputation, and two case of unilateral upper limb amputation. Fasciotomy was performed in three patients, including the two patients who did not undergo amputation. Moreover, one of these eight patients underwent craniotomy for removal of a cerebral hemorrhage and one patient underwent closed thoracic drainage. One patient underwent an enterectomy.

Cases 1 and 2, who did not undergo amputation, received transfusions and underwent CRRT from May 17th to 20th June, 2008, ultimately recovering well. Their renal function was normal in the late period of this study (after 30th June, 2008). Cases 3, 4, 5 and 6, who underwent 1 or 2 limb amputations and terminated their CRRT and transfusion treatment around 20th June, 2008, also made favorable progress, regaining their normal organ functions and internal environment homeostasis.

Case 7, a 40-year-old male, was diagnosed with crush syndrome after his right arm was crushed for 1 day. The amputation was performed 3 days after his admission.