Original Article

Application of bedside continuous blood purification in patients with multiple organ dysfunction syndromes

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BACKGROUND: The complications of systemic inflammatory response syndrome (SIRS) include acute lung injury, acute kidney injury, shock, and multiple organ dysfunction syndrome (MODS). In recent years, how to clear inflammatory mediators has become a hot topic in critical care medicine. Researchers hypothesize that continuous blood purification (CBP) can effectively eliminate a variety of inflammatory mediators which participate in the occurrence of MODS and adjust the immune imbalance. This study aimed to observe the effects of CBP in MODS patients.

METHODS: In this retrospective clinical study, a total of 38 MODS patients, 18 males and 20 females, were enrolled. After conventional therapy, all the patients received CBP. Biochemistry, blood gas analysis, oxygenation index, mean arterial blood pressure (MAP), acute physiology and chronic health evaluation (APACHE) II scores were monitored.

RESULTS: After CBP, the vital signs of patients were rapidly stable, and electrolyte disorders and acid-base imbalance were corrected. Renal function, blood gas, oxygenation index were all improved. MAP was increased, and APACHE II score was significantly decreased. All patients had good tolerance, stable hemodynamics, and no obvious adverse reaction on CBP compared with pre-CBP.

CONCLUSION: CBP can effectively clean toxins, correct electrolyte acid-base balance, and improve systemic inflammatory response syndrome and the organ function of MODS patients.

KEY WORDS: Systemic inflammatory response syndrome; Continuous blood purification; Multiple organ dysfunction syndromes

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INTRODUCTION

Systemic inflammatory response syndrome (SIRS) is an inflammatory state affecting the whole body, frequently a response of the immune system to infection caused by a variety of infectious and non-infectious factors. It is characterized by polymer-phosphonuclear cells adherence and macrophage activation, thereby activating the complement system, producing and releasing large amounts of inflammatory mediators. It also can trigger a series of chain-type reaction, destroy homeostasis and organ function, and thus lead to multiple organ dysfunction syndrome (MODS). Continuous arteriovenous hemofiltration (CAVH) was reported by Kramer et al^[1] in 1977 as a continuous treatment for patients with acute renal failure. Since then, the series of treatment models derived from CAVH have been named

as a continuous renal replacement therapy, also known as continuous blood purification (CBP). In recent years, how to clear inflammatory mediators has been a hot topic in critical care medicine. Researchers hypothesize that CBP can effectively eliminate a variety of inflammatory mediators which participate in the occurrence of multiple organ dysfunction syndrome, adjust the immune imbalance, and improve the MODS prognosis. The present study aimed to observe the effects of CBP on MODS patients.

METHODS

Patients

In this retrospective clinical study, a total of 38 MODS patients, 18 males and 20 females, age (62.1±10.9) years,

were enrolled. The patients were admitted to ICU in the Second Hospital of Jilin University, Changchun, China, from January 2008 to December 2010.

Diagnosis and treatment

The diagnosis of MODS was made according to the Diagnostic Criteria for MODS set up at the Third National Emergency Conference in Lushan in 1995.^[2] The primary diseases included severe pneumonia in 5 patients, septic shock in 6, severe acute pancreatitis in 7, cardiopulmonary resuscitation in 8, pregnancy hypertension in 5, myocardial infarction in 3, multiple trauma in 2, and drug poisoning in 2. Failure of two organs was seen in 15 patients, 3 organs in 12 patients, 4 organs in 6 patients, 5 organs in 4 patients, and 6 organs in 1 patient. APACHE II score was 22.52 ± 5.46 , and sequential organ failure assessment (SOFA) score was 10.5 ± 3.9 .

CBP treatment

External circulation was established by bi-cavity cannulation on the femoral vein using the Seldinger's method.^[3] Bedsides, continuous high-flow hemofiltration was performed at least one time every 3 days, and the filter was replaced every 24 hours. Treatment parameters were set as: blood flow 200-250 mL/min, replacement fluid flow 4L/h [mean dose of $63 \cdot 8 \text{ mL} / (\text{kg} \cdot \text{h})$], before/after dilution adjusted based on blood biochemistry and arterial blood gas analysis, common heparin as anticoagulation, and activated clotting time (ACT) at 150-180 seconds. Non-heparin therapy was used in patients with hemorrhage tendency, and the net ultra-filtration volume was regulated according to the needs of patients and the 24-hour amount of intake and output. All patients received anti-infection treatment, organ support and nutritional support, and comprehensive treatment after admission.

Parameters

Vital signs were recorded per 30 minutes during

CBP, including temperature (T), heart rate (HR), respiratory rate (RR) and mean arterial pressure (MAP). Also detected were arterial blood lactate (Lac) and pH, arterial partial pressure of oxygen (PaO_2), blood urea nitrogen (BUN), creatinine (Cr), bilirubin (BIL), sodium ion (Na) concentration, potassium ion (K) concentration, platelet count (PLT), and APACHE II score,^[4] SOFA score^[5] and oxygenation index at 24, 48, 72 hours before and after treatment. These parameters were compared before and after the treatment. During the course of the treatment, the overall conditions of the patients and their complications were closely monitored, and the safety of the treatment was predicted.

Statistical analysis

Statistical analysis was made with SPSS13.0 software for Windows, and the data were expressed as mean $\pm$ standard deviation. Student's *t* test was used for comparison of the parameters between before and after the treatment. $P < 0.05$ was considered statistically significant.

RESULTS

Basic vital signs and disease score before and after the treatment

Compared with those before the treatment, APACHE II score and SOFA score were significantly improved ($P < 0.01$). Moreover, compared with those before the treatment, heart rate, blood pressure, pulse, oxygenation index of the basic vital signs were also significantly improved ($P < 0.05$) (Table 1).

Comparison of renal function and electrolytes before and after CBP treatment

After CBP treatment, BUN and Scr were significantly decreased ($P < 0.01$); compared with those before CBP treatment, electrolytes were stable, and serum K^+ , Na^+ , and Cl^- didn't have significant changes ($P > 0.05$) (Table 2).

Table 1. Basic vital signs and disease score before and after CRRT treatment

Time points	APACHE II	SOFA	Oxygenation index	MAP (mmHg)	Respiration rate (time/min)	Heart rate (time/min)
Before	27.2 ± 6.1	11.6 ± 3.2	75 ± 21	42 ± 3	36.2 ± 2.6	135 ± 12
After	$18.5 \pm 3.5^*$	$8.4 \pm 2.6^*$	$243 \pm 26^\Delta$	$68 \pm 11^\Delta$	$21.2 \pm 1.4^\Delta$	$86 \pm 11^\Delta$

Compared with the group before CRRT treatment, $^*P < 0.01$; compared with the group before CRRT treatment, $^\Delta P < 0.05$.

Table 2. Comparison of renal function and electrolytes before and after CBP treatment

Time points	K^+ (mmol/L)	Na^+ (mmol/L)	Cl^- (mmol/L)	CRE ($\mu\text{mol/L}$)	BUN (mmol/L)
Before	4.9 ± 1.3	151 ± 13.2	102 ± 1.5	486 ± 32	31.2 ± 10.3
After	$4.0 \pm 0.9^\Delta$	$146 \pm 12.2^\Delta$	$101 \pm 2.1^\Delta$	$159 \pm 35^*$	$12 \pm 3.1^*$

Compared with the group before CRRT treatment, $^*P < 0.01$; compared with the group before CRRT treatment, $^\Delta P < 0.05$.

Clinical prognosis

In the 38 MODS patients, 4 were cured (2-3 organs failure), and 22 were improved (2-4 organs failure). The total efficient rate (cure and improvement) was 55.6%, and 12 patients died from failure of 3-5 organs, with a mortality of 45.60%.

DISCUSSION

SIRS^[6] is a serious condition related to systemic inflammation, organ dysfunction, and organ failure. It is a subset of cytokine storm, in which there is abnormal regulation of various cytokines. The causes of SIRS are considered infectious or noninfectious. When SIRS is due to an infection, it is considered sepsis. Noninfectious causes of SIRS include trauma, burns, pancreatitis, ischemia, and hemorrhage. SIRS is frequently complicated by failure of one or more organs or organ systems. The complications of SIRS include acute lung injury, acute kidney injury, shock, and multiple organ dysfunction syndrome (MODS).^[7,8]

MODS is the presence of altered organ function in acutely ill patients whose homeostasis cannot be maintained without intervention. It usually involves two or more organ systems. MODS usually results from excessive releasing inflammatory cytokines and neurotransmitters, whether there are infectious or non-infectious causes. In 1977, continuous arteriovenous hemofiltration (CAVH) was reported by Kramer et al^[1] as a continuous treatment for patients with acute renal failure. Since then, various other regimens for continuous renal replacement therapy, for example, continuous blood purification (CBP), have been developed.^[9,10] CBP is mainly used to remove inflammatory mediators contributing to the occurrence of MODS.^[11-16]

In our study, we found that after CBP treatment, water content, electrolytes and acid-base balance disorders were corrected in the MODS patients, azotemia was prevented, and internal environment was maintained. The functions of the heart, lung, brain, and kidney were protected. In addition, BUN and CRE significantly reduced, and serum potassium, sodium and chloride remained normal.^[17,18] This finding indicated that CBP exerted better scavenge effect on small molecules, effectively corrected the electrolyte imbalance. In the 38 patients, the basic vital signs were corrected after CBP treatment, and hemodynamics was stable during the treatment, and the patients were tolerated well during the CBP treatment. Compared with those before HVHF treatment, MAP, PaO₂, and PaO₂/FiO₂ were significantly

increased, but PaCO₂ was decreased. SOFA score and APACHE II score were significantly decreased. This indicated that HVHF improved the prognosis of MODS patients.^[19]

In conclusion, CBP can improve hemodynamics and oxygenation of MODS patients, rebuild the immune homeostasis, improve microcirculation, increase organizational oxygen uptake, and thus effectively improve the survival of the patients.

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