

## Original Article

# Evaluation of therapeutic effect of continuous blood purification on aged patients with severe heart failure

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**Abstract:** Objective: To investigate the clinical effect of continuous blood purification (CBP) on aged patients with severe heart failure. Methods: The clinical data of 90 aged patients with severe heart failure treated by CBP from June, 2011 to June, 2016 were analyzed retrospectively. The changes of blood biochemistry, blood gas analysis, blood pressure, respiration, heart rate, oxygenation index and so on were recorded and treatment effects were observed before treatment and at 72 h after treatment. Results: Among 90 patients treated with CBP, marked effects were seen in 80 cases, general effect in 8 cases and death in 2 cases, with the total effective rate of 97.8%. The differences between before treatment and 72 h after treatment, in the heart rate ( $P<0.001$ ), respiration rate ( $P<0.001$ ), central venous pressure ( $P=0.003$ ), mean arterial pressure ( $P=0.049$ ), oxygenation index ( $P<0.001$ ), biochemical indicators (including BUN, SCr,  $\text{HCO}_3^-$  and BNP, all  $P<0.001$ ), blood gas indexes (including pH,  $\text{PaO}_2$ ,  $\text{PaCO}_2$ ,  $\text{SaO}_2$ , all  $P<0.001$ ), and cardiac function indexes (including SV, CO, LVEF,  $P<0.001$ ), were statistically significant. Conclusion: CBP has positive curative effects on aged patients with severe heart failure and can significantly improve their cardiac function and reduce the incidence of adverse reactions.

**Keywords:** Continuous blood purification, aged patients with severe heart failure, treatment strategy

## Introduction

Clinically, there are many aged patients suffered from severe heart failure [1]. At present, they are usually treated with cardiac, diuretic, blood vessels expand and so on, but most patients have poor responses to these treatments [2]. Especially the patients with heart failure accompanied by renal failure, the vicious cycle can be formed due to the mutual aggravation of renal failure and heart failure. The blood purification is the main method for the treatment of renal failure, now, it is also considered as an effective clinical treatment for aged patients with severe heart failure.

Conventional hemodialysis has a great impact on the hemodynamics of patients. Considering the poor tolerance of aged patients, it can cause greater damage on these elderly patients with severe heart failure [3]. Therefore, the clinical application of conventional hemodialysis is limited. Continuous blood purification (CBP) is a generic term for all the treatment method

of removing water and solute continuously and slowly. CBP can remove the retention of water and solute in patients stably and maintain the hemodynamic stability, significantly reduce the preload of the heart, improve cardiac function, relieve the symptoms of shortness of breath and edema, thereby, improve the quality of life. Consequently, CBP is an important method for the treatment of obstinate heart failure [4-6].

To further investigate the clinical efficacy of CBP, a retrospective analysis was conducted on the data of 90 aged patients with severe heart failure. The research procedure and result were as follows.

## Materials and methods

### General information

The elderly patients with severe heart failure, treated with CBP from June 2011 to June 2016, were included in this study. This study aimed to evaluate the therapeutic effect of CBP on them. The research was approved by Ethics Committee

of hospital and informed consents for treatment were signed by patients and their families.

### *Therapeutic method*

Vascular access was constructed by implanting two-way catheter into femoral vein. Aquarius continuous blood purification apparatus produced by Baxter and FILTRAL16 filter (AN69 membrane) produced by Hospal Industrie were used in this study. Formula of substitution fluid (4 L/bag): 0.9% NaCl 3000 ml, 5% glucose 170 ml, water for injection 820 ml, 10% CaCl<sub>2</sub> 6.4 ml and 50% MgSO<sub>4</sub> 1.6 ml (Asolution). And the B solution (250 ml) consisted of 10% KCL and 5% NaHCO<sub>3</sub> and was made according to the serum potassium level of patients. They were injected synchronously by different accesses in proportion of (4000 ml A fluid: 250 ml NaCHO<sub>3</sub>). The B fluid was not mixed with the A fluid to avoid ion precipitation. Throughout the course of the treatment, 5% NaHCO<sub>3</sub> was added at a constant speed to correct acidosis and the electrolyte concentration was adjusted according to the actual condition of patients. The flow of substitution fluid was 1.5-2.0 L/h and the blood flow was 180-220 ml/min. The treatment lasted for 72 hours. During the treatment, all the patients were treated with femoral vein catheterization and heparin anticoagulation. The heparin liquid was first used to flush the tube, and then the low molecular weight heparin was injected intravenously for anticoagulation with the first dose of 4000 U. Heparin-free or in vitro heparinization would be applied if there was a bleeding tendency. Activated coagulation time (ACT) was measured every 2 to 4 hours and the heparin dose was adjusted according to the level of ACT [7].

### *Observation index*

The heart rate, blood pressure, respiration, central venous pressure (CVP), mean arterial pressure (MAP), oxygenation index (OI), blood urea nitrogen (BUN), serum creatinine (SCr), and fluid, electrolyte and acid-base disorders of patients were measured before and after treatment. BUN, SCr, serum potassium (K<sup>+</sup>), bicarbonate ion (HCO<sub>3</sub><sup>-</sup>) and pH value were detected respectively before treatment and at 72 h after treatment. At the same time, Cardiac Color Doppler Echocardiography was applied into the examination before treatment and at 72 h after

treatment to determine the changes of cardiac function.

### *Criteria of curative effects*

In this self-controlled clinical trial, it could be found that the clinical symptoms, signs and all the examination results were improved obviously compared with pre-operation. Criteria of clinical efficacy were as follows. Significant effect: the clinical symptoms, signs and all the clinical examination results of patients were obviously improved, the cardiac function improved above NYHA II, the urine volume increased, the renal function indexes returned to normal, and patients were independent of dialysis; General effect: the clinical signs, symptoms and all the examination results were improved to some extent. The cardiac function improved above NYHA I, the increase of urine volume was unobvious, the renal function failed to improve and dialysis was still necessary. No effect: the cardiac function of patients failed to improve and patients terminated hemofiltration or died because of the aggravation of heart failure or the intolerance of hemofiltration. Total effective rate=marked effect rate + general effect rate.

### *Statistical analysis*

SPSS 13.0 software was adopted for statistical analysis. The measurement data was expressed as mean ± standard deviation (mean ± sd) and analyzed with the paired t-test. P<0.05 indicated that differences were statistically significant.

## **Results**

### *Basic information*

Ninety patients (49 males and 41 females), aged 67-87 years, with the average age of (76±10.5) years, were enrolled. All the patients have heart failure symptoms such as palpitation, shortness of breath, systemic severe edema pulmonary edema, jugular venous distention, cardiomegaly, etc. Diagnostic criteria was referred to the New York Heart Association Functional Classification (NYHA-FC): 39 cases in NYHA III, 51 cases in NYHA IV, and left ventricular ejection fraction (LEVF) was 18%-32%. Among 90 patients, there were 40 cases of coronary atherosclerotic heart disease, 25 cases of hypertensive heart disease, 13 cases

# Curative effect of CBP on aged patients with severe heart failure

**Table 1.** Basic information of recruited patients

	Age (year)	Sex		NYHA classification		Related diseases				
		Male	Female	III	IV	CHD	HHD	DC	RHD	PHD
Selected patients	76±10.5	49	41	39	51	40	25	13	8	4

Note: CHD, Coronary heart disease; HHD, Hypertensive heart disease; DC, Dilated cardiomyopathy; RHD, Rheumatic heart disease; PHD, pulmonary heart disease.

**Table 2.** Comparison of changes in respiratory circulation, and arteriovenous pressure before and after CBP treatment (mean ± sd)

Items	Heart rate (beat/min)	Respiration (breath/min)	OI (mmHg)	CVP (cmH <sub>2</sub> O)	MAP (mmHg)
Before treatment	120.3±25.1	36.8±5.8	132.2±39.9	15.8±5.9	83.3±15.4
72 h after treatment	108.5±17.4	23.7±4.6	156.8±36.9	13.5±4.2	79.1±12.9
t	3.67	16.79	-4.30	3.01	1.98
P	<0.001	<0.001	<0.001	0.003	0.049

**Table 3.** Biochemical changes of patients before and after CBP treatment (mean ± sd)

Items	BUN (mmol/L)	SCr (mmol/L)	K <sup>+</sup> (mmol/L)	HCO <sub>3</sub> <sup>-</sup> (mmol/L)	BNP (pg/ml)
Before treatment	25.5±10.5	390.9±160.3	5.2±0.6	9.5±2.2	945.7±801.4
72 h after treatment	10.5±5.2	193.3±88.4	4.2±0.3	23.5±5.1	261.5±228.5
t	12.14	10.24	14.14	-23.91	7.79
P	<0.001	<0.001	<0.001	<0.001	<0.001

**Table 4.** Changes of blood gas indexes in patients before and after CBP treatment (mean ± sd)

Items	pH	PaO <sub>2</sub> (mmHg)	PaCO <sub>2</sub> (mmHg)	SaO <sub>2</sub> (%)
Before treatment	7.2±0.3	43.2±6.8	56.1±8.1	62.3±8.4
72 h after treatment	7.4±0.1	70.2±7.2	42.2±8.2	91.2±9.6
t	-6.00	-25.86	11.44	-21.49
P	<0.001	<0.001	<0.001	<0.001

of dilated cardiomyopathy, 8 cases of rheumatic valvular heart disease, and 4 cases of pulmonary heart disease. Besides, 32 patients were complicated with severe pulmonary infection, and 27 patients were complicated with renal failure. All patients received anti-heart failure treatment such as cardiotonic agents, diuretics, vasodilators and so on, but the result was not good (**Table 1**).

## Changes of conditions of patients

After CBP treatment, the marked effects were seen in 80 cases; general effects in 8 cases; death in 2 cases, with the total effective rate of 97.8%. Two patients suffered from cardiogenic shock and malignant arrhythmia which could not be remedied in the CBP process, and died

due to the intolerance of CBP treatment. However, after CBP treatment, the improvements of heart function of the last 88 patients were comparatively obvious, their edema and moist crackles in both lungs were significantly reduced. In addition, the heart rates and respiratory rates of these 88 patients were decreased compared with preoperative ones and the oxygenation function was also improved. By comparison, the differences between pretreatment and 72 h after treatment in heart rate ( $P<0.001$ ), respiration ( $P<0.001$ ), CVP ( $P=0.003$ ), MAP ( $P=0.049$ ) and OI ( $P<0.001$ ) of all patients were statistically significant (**Table 2**).

## Changes of biochemical indexes

According to the blood biochemical examination in patients at 72 h after treatment, the levels of BUN ( $P<0.001$ ), SCr ( $P<0.001$ ), K<sup>+</sup> ( $P<0.001$ ) and BNP ( $P<0.001$ ) were significantly reduced, while HCO<sub>3</sub><sup>-</sup> ( $P<0.001$ ) was significantly increased to the normal level. The differences were statistically significant compared with those before treatment (**Table 3**).

**Table 5.** Changes of cardiac function indexes in patients before and after CBP treatment (mean  $\pm$  sd)

Items	SV (ml/beat)	CO (L/min)	LVEF (%)
Before treatment	29.6 $\pm$ 3.9	2.5 $\pm$ 1.1	38.8 $\pm$ 5.4
72 h after treatment	55.8 $\pm$ 5.8	4.3 $\pm$ 0.4	59.5 $\pm$ 4.1
t	-35.56	-14.59	-28.96
P	<0.001	<0.001	<0.001

#### Changes of blood gas indexes

The detection showed that the differences between pretreatment and 72 h after treatment in the indexes of pH ( $P<0.001$ ),  $\text{PaO}_2$  ( $P<0.001$ ),  $\text{PaCO}_2$  ( $P<0.001$ ) and  $\text{SaO}_2$  ( $P<0.001$ ) of blood gas were statistically significance (**Table 4**). The values of pH,  $\text{PaO}_2$ ,  $\text{PaCO}_2$  and  $\text{SaO}_2$  could quickly return to normal level and 16 patients could gradually stop using ventilator.

#### Comparison of echocardiographic indexes

The Color Doppler Echocardiography was adopted to examine the relative indexes before and after the treatment of CBP. The indexes included stroke volume (SV), cardiac output (CO) and left ventricular ejection fraction (LVEF). And the differences in these indexes between pretreatment and 72 h after treatment were statistically significant (all  $P<0.001$ , **Table 5**).

#### Discussion

Nowadays, heart failure threatens the health and safety of human with high mortality and poor prognosis [8]. It is a terminal stage of all kinds of heart diseases. Aged patients with heart failure have the symptom of decreased CO, leading to abnormality of kidney blood distribution, blood stasis and edema of kidney, decrease of glomerular filtration rate. As a result, the renal function is impaired to some degree. Accordingly, the sensitiveness of patients to diuretics is reduced, resulting in the poor effect of diuretics. Meanwhile, the massive usage of diuretics can cause the disorder of internal environment in the body, the imbalance of electrolyte, the increase of complications and the aggravation of disease [9].

ACC/AHA 2009 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult and ESC guidelines for the diag-

nosis and treatment of acute and chronic heart failure 2016 recommend CBP as a treatment method of obstinate heart failure [10-12]. CBP, as an advancement in treating aged patients with severe heart failure in recent years, has the following advantages. First, CBP can clean out water, low molecule weight toxins and etc. continuously and slowly to ensure the hemodynamic stabilization and patients' good tolerance. Second, it can control azotemia and regulate the balance of electrolyte and water-salt metabolism more quickly and accurately [13]. Third, it can wipe out inflammatory mediators like tumor necrosis factor- $\alpha$ , interleukin-6 and interleukin-8 in circulation continuously [14]. Fourth, CBP can clean up brain natriuretic peptide which is the related marker of prognosis and stratification of obstinate heart failure. Last, CBP can remove the large quantities of water from intracellular fluid in short time and stabilize the cardiovascular system [15]. Therefore, CBP is suitable to aged patients, especially to those hypotensive patients with steady cardiovascular [16].

In this study, after CBP treatment, the clinical symptoms of 88 patients were improved obviously as compared with those before treatment. The results showed the disappeared edemas and reduced moist crackles of lungs, which was in agreement with the results of previous studies. The previous research has found that CBP can clean out the water in the body continuously and slowly and decrease cardiac preload [17]. Another possible reason of the agreement is that CBP can ease perfusion pressure of pulmonary circulation and result in the decrease of central venous pressure and pulmonary artery pressure [12]. Meanwhile, the results of our study proved that the arterial blood gas indexes ( $\text{PaO}_2$ ,  $\text{PaCO}_2$  and  $\text{SaO}_2$ ) and cardiac function indexes (heart rate and respiratory rate) of patients were improved after CBP treatment. It may be related to the application of synthetic membrane transfusion filters in the CBP treatment, which can wipe out the inflammatory mediators in vessel and then ensure the organism oxygenation and promote the recovery of cardio-pulmonary function [18].

Besides, the levels of BUN, Scr,  $\text{K}^+$  and pH value of patients were decreased after CBP treatments, maintaining the stability of internal environment. The possible reason is that CBP can lighten renal interstitial edema, increase cardi-

ac perfusion, improve renal function, promote the effect of diuretics, and further maintain the electrolyte and acid-base balance in vivo and ensure the stability of internal environment [19]. The Color Doppler Echocardiography indicated that the SV, CO and ejection fraction (LVEF) value were improved after treatment. It was in line with the related research which proved that ventricular diameter was narrowed and cardiac LVEF and SV were increased after CBP treatment [20, 21]. After CBP treatment, there were 2 cases of death and the total effective rate was 97.8%. These two patients had symptoms of malignant arrhythmia after CBP treatment and died from ineffectual rescues, which were caused by uncontrollable factors instead of the treatment of CBP.

In conclusion, CBP technology can obviously improve the clinical symptoms and heart function of aged patients with severe heart failure. Meanwhile it also can decrease the rate of adverse reactions. However, other factors like the long-term life quality and survival rate of patients are not observed and the sample capacity is relatively small, which may lead to the deviations of results. Therefore, further studies with larger sample capacity and longer follow-up period will be done to determine the curative effect of CBP and to have the CBP technology widely applied in clinic.

## Disclosure of conflict of interest

None.

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