Clinical Efficacy of Blood Ultrafiltration Therapy in Patients with Acute Decompensated Chronic Heart Failure

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Summary

In this study, we investigated the clinical effects of blood ultrafiltration therapy in patients with acute decompensated chronic heart failure. We enrolled 78 patients with acute decompensated chronic heart failure who were admitted to a hospital from September 2017 to December 2021, and divided them into two groups based on the digital randomization method. The FQ-16 heart failure ultrafiltration dehydrating device blood ultrafiltration therapy was administered to the observation group (39 patients) for 8-16 hours, while the control group (39 patients) received the stepped drug therapy. Echocardiography was used to assess the changes in cardiac function of the patients in both groups before and after treatment. The changes in urine volume, N-terminal pro-B-type natriuretic peptide (NT-proBNP), plasma renin, and serum creatinine levels were measured before and after the treatment to compare the overall response rate of the patients in both groups. The differences in left ventricular end-systolic dimension and left ventricular end-diastolic dimension and the ejection fraction between the groups before treatment were not statistically significant (P>0.05), however, the left ventricular end-diastolic dimension in the observation group was significantly lower and the ejection fraction was significantly higher (P<0.05) compared with that before treatment; the urine volume, N-terminal pro-B-type natriuretic peptide (NT-proBNP), plasma renin, and serum creatinine were significantly improved in both groups after treatment compared with that before treatment. All indexes in the observation group were better than those in the control group (P<0.05), 74.36 %. The overall response rate of the observation group was 94.87 %, x^2 = 4.843 and the difference between groups was statistically significant (P<0.05). Blood ultrafiltration therapy for patients with acute decompensated chronic heart failure can improve their cardiac and renal functions, reduce NT-proBNP, reduce volume load, and enhance efficacy while ensuring high safety.

Keywords

Blood ultrafiltration • Chronic heart failure • Decompensated phase

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Introduction

Dyspnea, fatigue, and fluid retention are the main symptoms of heart failure, which is a group of syndromes caused by impaired ventricular filling and ejection capacity due to structural or functional heart disease [1,2]. Fluid overload is a key pathophysiological mechanism of acute decompensated chronic heart failure (ADHF) [3-4]. However, blood ultrafiltration has shown promising results in clinical practice for treating water-sodium retention, thereby alleviating dyspnea and fluid retention in heart failure patients [5]. In this study, we analyzed the effect of blood ultrafiltration therapy in patients with ADHF.

Material and Methods

General information

We enrolled 78 patients with chronic heart failure associated with ventricular arrhythmias admitted to our hospital from September 2017 to December 2020,

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and divided them into two groups based on the digital randomization method. There were a total of 39 patients split evenly between the control and observation groups. The difference in basic information between the two groups of patients was not statistically significant (P>0.05), as shown in Table 1AB. The patients signed the informed consent form, and this clinical study was approved by the Ethics Committee of the hospital.

Table 1A Comparison of general information of patients in both groups

Group	n	Gender		Average age	NYHA Classification	
		Male	Female	(years)	Class III	Class IV
Control group	39	21	18	57.2±4.04	32	7
Observation group	39	24	15	56.3±4.72	29	10
t/x^2	-	0.437		0.992	0.494	
P	-	0.514		0.330	0.588	

Table 1B Comparison of general information of patients in both groups

Group	n	Basic diseases			Disease duration (years)
		Coronary heart disease	Cardiomyopathy	Valvular heart disease	
Control group	39	12	15	8	4.93±0.33
Observation group	39	16	14	6	5.15±0.70
t/x^2	-	0.394	0.053	0.347	1.783
P	-	0.531	0.821	0.563	0.082

Inclusion and exclusion criteria

Inclusion criteria: Satisfied the diagnostic criteria of chronic heart failure stipulated in the *Chinese Guidelines for the Diagnosis and Management of Heart Failure* (2018) [5] and the diagnostic criteria of ventricular arrhythmias in the *Practical Clinical Arrhythmia Diagnosis and Treatment Guidelines* (2003) [6]; diagnosis confirmed in combination with dynamic electrocardiogram (DCG) and echocardiography; signed informed consent and volunteered to participate in this study; left ventricular ejection fraction (LVEF) ≤ 40 % and early to late diastolic transmitral flow velocity (E/A) ≤ 1.0; New York Heart Association (NYHA) classification as Class III–IV.

Exclusion criteria: Ventricular arrhythmias due to drug intoxication or myocardial infarction; suffering from hematological diseases, malignant tumors, thyroid dysfunction, etc.; with degree II or above atrioventricular block/sinus bradycardia (atrioventricular block degree criteria: first degree, P-R>0.20; type I of the second degree, progressive prolongation of P-R with QRS detachment; type II of the second degree, QRS detachment but no progressive prolongation of P-R; third degree, P wave, and QRS are not associated, with their frequencies), congenital heart disease, cardiogenic shock, and corrected QTc>0.50 s; with severe skin, gastrointestinal, or systemic severe allergy to experimental drugs, and with poor treatment compliance.

Methods

The patients in the control group were given the standard treatment for heart failure as per the *Guidelines for the Diagnosis and Management of Heart Failure*, and were administered diuretics, cardiac drugs, vasodilators, angiotensin-converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB), aldosterone receptor antagonists, and other drugs such as sacubitril/valsartan (ARNI—angiotensin receptor/ neprilysin inhibitor), dopamine, dobutamine, milrinone, levosimendan, etc., as appropriate. The original

conditions were controlled and β-blockers were administered depending on the condition of the patient after they were stabilized.

The patients in the observation group were administered 8–16 hours of blood ultrafiltration therapy with post-filter connection, ultrafiltration speed of 200–300 mL/h, and blood pump speed of 20–40 mL/min. Low-molecular heparin 100 U/kg was administered intravenously 30 min before ultrafiltration and an additional half dose was given 6–8 h after the treatment. The heparin dosage was adjusted if the patient had a history of bleeding or there was combined hepatic and renal insufficiency. Blood ultrafiltration therapy did not involve the use of diuretics; instead, diuretics were given at the end of treatment in response to the patient's condition. The FQ-16 heart failure ultrafiltration dehydration device (Beijing Hatkel Medical Technology Co., Ltd.) was used for extracorporeal blood ultrafiltration; the extracorporeal circulation pipeline used for ultrafiltration was from Jiangsu Shagong Medical Device Technology Development Co., Ltd., and the Hemocor HPH 400 filter was from Minitech, United States.

Efficacy determination criteria

Patient's symptoms, signs, ventricular premature beats, atrial fibrillation, conduction block, and NYHA classification were used to determine the efficacy.

The criteria for marked response were: The symptoms and signs of the patients disappeared or disappeared at the end of the treatment, NYHA classification improved ≥ Class 2, premature ventricular beats decreased by more than 60 %, frequent ventricular premature beats and atrial fibrillation disappeared or converted to episodic (decreased more than 80 %), paroxysmal tachycardia completely converted to sinus rhythm, and electrocardiogram and cardiac enzymes returned to normal.

The criteria for response were: The clinical symptoms and signs of the patients improved significantly after treatment, NYHA classification improved by Class 1, ventricular premature beats decreased by more than 30 %, paired ventricular premature beats decreased by more than 40 %, paroxysmal tachycardia converted to sinus rhythm with a duration time<10 min, and electrocardiogram and cardiac enzyme indexes returned to normal.

The criteria for failure were: Failure to improve symptoms, signs, ventricular premature beats, atrial fibrillation, tachycardia, conduction block, and NYHA classification, as well as ventricular premature beats after treatment, or the condition worsened. Overall response rate = (Marked response + Response) / Total number of patients.

Observation indicators

- The patients in both groups underwent echocardiography within 24 h of admission and 3 d after treatment, including left ventricular end-diastolic dimension, left ventricular end-systolic dimension, and left ventricular ejection fraction.

- The weight, urine volume, and N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels of the patients in both groups were compared before and 3 d after treatment.

Statistical methods

SPSS20.0 statistical software was used to process the test data. Count data are expressed as percentage, the chi-squared test was used for inter-group data, measurement data are expressed as mean ± standard deviation, the *t*-test was used for data conforming to a normal distribution, and the non-parametric test was used for data not conforming to normal distribution. $P<0.05$ indicated that the differences were statistically significant.

Results

Comparison of treatment efficiency

The overall response rate of the treatment for patients was 74.36 %, and 94.87 % for the control group and the observation group with the combined medication, respectively, $x^2 = 4.843$, $P<0.05$, as shown in Table 2.

Changes in cardiac function indicators before and after treatment

The LVEF and stroke volume (V) were significantly higher in both groups after treatment; the values were higher in the observation group compared to the control group, and the difference was statistically significant ($P<0.05$). In contrast, left ventricular end-diastolic diameter (LVEDD) and left ventricle end-systolic dimension (LVESD) were significantly lower, and there was statistically significant difference in intergroup values after treatment ($P<0.05$), as shown in Table 3.

Table 2. Comparison of the overall response rate for palliative care of patients in both groups [n (%)]

Group	n	Marked response	Response	Failure	Overall response rate
Control group	39	14(35.90)	15(38.46)	10(25.64)	74.36
Observation group	39	26(66.67)	11(28.21)	2(5.13)	94.87
x^2					4.842
P					0.033

Table 3. Improvement of cardiac function indicators in patients in both groups before and after treatment ($\bar{x}$ ±s)

Indicators	Time	Control group(39)	Observation group(39)	*t*	*P*
LVEF(%)	Before treatment	33.58±8.05	33.67±6.77	0.58	0.952
	After treatment	47.23±5.22*	51.14±6.30*	3.24	0.000
LVEDD(mm)	Before treatment	66.25±4.61	65.88±5.30	0.36	0.720
	After treatment	60.96±5.07*	58.29±4.55*	2.66	0.014
LVESD(mm)	Before treatment	57.48±4.23	54.15±3.92*	0.12	0.902
	After treatment	57.60±5.12	52.33±4.40*	2.10	0.042
SV(L/min)	Before treatment	3.28±0.22	4.48±0.63*	1.28	0.214
	After treatment	3.35±0.30	4.82±0.51*	2.85	0.016

(Note: * Intra-group comparison before and after treatment, $P < 0.05$)

Table 4. Comparison of weight, urine volume, and NT-ProBNP levels in patients in both groups before and after treatment (x±s)

Group	Weight (kg)		Urine volume (ml/d)		NT-proBNP(pg/ml)	
	Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control group (n=39)	63.20±10.27	62.17±13.34	885.63±152.30	1520.14±412.03	11024.36±584.20	9123.52±742.36
Observation group (n=39)	63.03±8.62	58.03±10.85	896.41±184.02	2105.36±563.42	12024.17±741.36	7154.26±526.97
t	0.533	4.024	0.224	6.021	0.674	2.736
P	0.424	0.000	0.854	0.000	0.460	0.011

Changes in weight, urine volume, and NT-proBNP levels of the patients in both groups before and after treatment

The difference in weight of the patients in the control group before and after treatment was not statistically significant ($P>0.05$); the weight of the patients in the observation group decreased after treatment compared with that before treatment, and the difference was statistically significant ($P<0.05$). The urine volume of the patients in both groups increased after treatment, and the difference was statistically significant in the observation group ($P<0.05$). The NT-proBNP levels of the patients in the observation group decreased after treatment compared with that before treatment and the difference was more significant than that in the control group ($P<0.05$), as shown in Table 4.

Comparison of hospitalization days before and after treatment between the two groups

The length of hospitalization was 10.29±2.61 days in the observation group and 13.68±3.73 days in the control group. The difference was statistically significant ($P<0.0001$), as shown in Figure 1.

Comparison of ventricular pre-systole, atrial pre-systole, and paroxysmal tachycardia between the two groups before and after treatment

The ratio of pre-systole and tachycardia before treatment was 25.12 %±3.45 % in the observation group, and 8.36 %±1.25 % after treatment. The ratio for the control group was 24.78 %±2.78 % before treatment and 22.91 %±3.52 % after treatment. After treatment, the difference between the observation group and the control group was statistically significant (P<0.001), as shown in Figure 2.

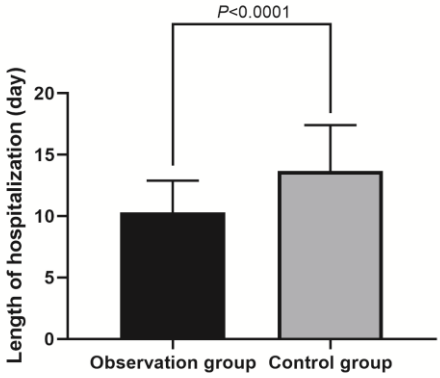

Fig. 1. Comparison of hospitalization days of patients in both groups.

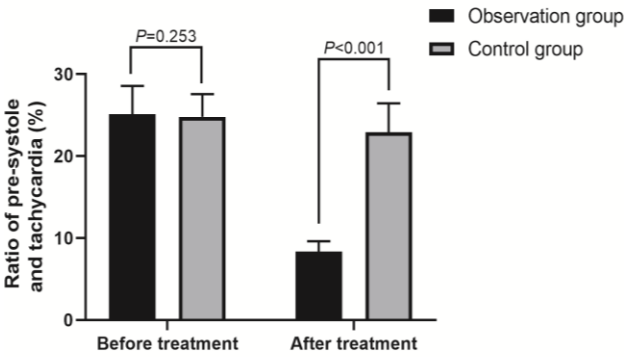

Fig. 2. Comparison of ventricular pre-systole, atrial pre-systole, and paroxysmal tachycardia in patients in both groups before and after treatment.

Discussion

According to estimates from the *China Cardiovascular Disease Report 2021*,[7] the number of people in China with cardiovascular diseases is currently around 330 million and rising. Patients with ADHF are typically hospitalized due to volume overload caused by heart failure. Although diuretics are currently the gold standard in pharmacological treatment for heart failure, patients with ADHF frequently experience side effects such as diuretic resistance, poor diuretic efficacy, electrolyte disturbances, and activation of the neuroendocrine system. Many patients still have difficulty controlling their volume load despite the use of standard diuretic therapy [8]. The data shows that after 4 days of diuretic treatment, 20 % of patients still did not experience a significant increase in urine volume or loss of weight. The likelihood of hospital readmission or death due to heart failure is linked to a patient's responsiveness to diuretics. Many patients eventually develop acute cardio-renal syndrome or refractory heart failure. As a result, there is a pressing need for additional therapies such as blood ultrafiltration for the treatment of heart failure [9,10].

The recommendations for ultrafiltration therapy in the *Chinese Guidelines for the Diagnosis and Management of Heart Failure (2018)* [5] are for patients with significant fluid retention (e.g., pulmonary edema or severe peripheral edema) combined with poor diuretic response or diuretic resistance (Level of evidence: IIa, B), and for patients with refractory end-stage heart failure who have significant water-sodium retention and who can be treated with bedside ultrafiltration. When it comes to diagnosing heart failure, NT-proBNP is the gold standard biomarker. Differential diagnosis, risk rating, prognosis, and treatment monitoring of heart failure are all areas where NT-proBNP has been shown to be clinically significant [11-13]. At the same time, the concentration of NT-proBNP has a significant effect on the readmission rate of patients with ADHF.[14] In this study, patients in the observation group had lower NT-proBNP levels than those in the control group, suggesting that ultrafiltration therapy has the potential to boost patients' prognoses, cut down on hospitalizations, and enhance their quality of life. Bedside blood ultrafiltration has been shown in clinical trials to improve cardiac function, lower levels of brain natriuretic peptide (BNP), and increase safety compared to standard care [15]. The novel FQ-16 heart failure ultrafiltration device used in this study has the advantages of low blood flow rate, low blood volume in extracorporeal circulation, low blood chamber volume, does not require replacement fluid and dialysis solution, does not require frequent monitoring of electrolytes and blood gas analysis, utilizes a simple operation process, and is an effective therapeutic measure to correct the volume overload [16]. The results of this study show that blood ultrafiltration therapy is an effective method for treating patients with ADHF when compared to conventional therapy in terms of alleviating clinical symptoms, decreasing weight, increasing urine volume,

lowering NT-proBNP levels, decreasing volume load, and improving cardiac function. The clinical benefit of early use may be more significant.

The study has the following limitations: Firstly, the number of patients included was small, which may lead to bias in the study results. It is hoped that the sample is expanded in subsequent studies to obtain more accurate experimental data. Secondly, the long-term safety of the patients in both groups was not followed up.

In conclusion, patients with ADHF who undergo blood ultrafiltration therapy can benefit from a restoration of cardiac function, enhancement of renal function, decreased NT-proBNP, reduction of volume load, and improvement in efficacy.

Conflict of Interest

There is no conflict of interest.

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