Am J Transl Res 2021;13(4):2590-2598
www.ajtr.org /ISSN:1943-8141/AJTR0123853

Original Article

Clinical efficacy of ceftazidime combined with levofloxacin on heart failure complicated with pulmonary infection and its influence on cardiopulmonary function

Rong Yang[1*], Yuou Li[2*], Jinliang Li[3], Limin Xing[4], Li Liu[5]

[1]Department of Fundamental Medicine, Hubei College of Chinese Medicine, Jingzhou 434020, Hubei Province, China; [2]Department of Outpatient, Harbin Sixth Hospital, Harbin 150040, Heilongjiang Province, China; [3]Department of General Internal Medicine, Harbin Sixth Hospital, Harbin 150040, Heilongjiang Province, China; [4]Department of Nursing, Xiangyang No. 1 People's Hospital Affiliated to Hubei University of Medicine, Xiangyang 441000, Hubei Province, China; [5]Department of Cardiothoracic Surgery, Xiangyang No. 1 People's Hospital Affiliated to Hubei University of Medicine, Xiangyang 441000, Hubei Province, China. [*]Equal contributors and co-first authors.

Received October 10, 2020; Accepted November 27, 2020; Epub April 15, 2021; Published April 30, 2021

Abstract: Objective: This study was designed to analyze the clinical efficacy of ceftazidime combined with levofloxacin on heart failure complicated with pulmonary infection and its influence on cardiopulmonary function. Methods: A total of 124 patients with heart failure and pulmonary infection admitted to our hospital from June 2018 to October 2019 were divided into groups according to different treatment schemes. Thereinto, 60 patients who were given ceftazidime intravenous drip on the basis of routine treatment were included in group A, and 64 who were given levofloxacin hydrochloride injection based on intravenous drip in group A were included in group B. The clinical efficacy, cardiac and lung function, pathogenic bacteria, infection, immune indexes and adverse reactions before and after treatment were compared. Results: After treatment, the adjusted levels of LVEF, LVEDD and LA in group B after treatment were greater than those in group A ($P<0.05$); the levels of MMV, TLC and FEV1 in group B were increased more than those in group A ($P<0.05$). After treatment, the levels of BNP, PCT and CRP in groups A and B decreased compared with those before treatment ($P<0.05$). Furthermore, the down-regulated levels of BNP, PCT and CRP in group B were higher than those in group A after treatment ($P<0.05$). After treatment, the levels of serum $CD3^+$, $CD4^+$, $CD4^+/CD8^+$ in group B increased more and $CD8^+$ decreased more. The clinical efficacy of group B after 7 days was higher than that of group A ($P<0.01$). Patients were followed up for one month, and there was no marked difference in their adverse drug reaction rates ($P>0.05$). Conclusion: To sum up, ceftazidime combined with levofloxacin on patients with heart failure and pulmonary infection can improve the immune function while optimizing the clinical efficacy and cardiopulmonary function.

Keywords: Ceftazidime, levofloxacin, heart failure, pulmonary infection, cardiopulmonary function

Introduction

Heart failure, as a common disease, is the familiar clinical manifestation of most organic heart diseases from progression to the end stage [1-4]. Patients with heart failure are often accompanied with secondary diseases such as pulmonary circulation congestion and edema, which create certain conditions for pathogenic bacteria to invade [5, 6]. Therefore, the risk of pulmonary infection in patients with heart failure is relatively high. While the population is aging more and more seriously, the morbidity of pulmonary infection in patients with heart failure is increasing year by year [7, 8]. It is therefore, a unique challenge to achieve effective and safe anti-pathogenic bacteria infection in patients with heart failure and pulmonary infection [9, 10]. Timely and effective infection control and anti-inflammatory treatment is vital to improve the prognosis of patients with heart failure and pulmonary infection. After pulmonary infection control, heart failure can be partially improved [11].

At present, ceftazidime combined with levofloxacin is often used to treat patients with pulmonary infection [12-14]. Ceftazidine, as the third

Table 1. General data

Group	Group A (60)	Group B (64)	X^2/t	P
Age	61.52±4.65	63.13±4.46	1.968	0.051
Gender			0.055	0.815
Male	25 (41.67)	28 (43.75)		
Female	35 (58.33)	36 (56.25)		
Hypertension			0.000	1.000
Yes	60 (100.00)	64 (100.00)		
No	0 (0.00)	0 (0.00)		
Diabetes			0.022	0.882
Yes	51 (85.00)	55 (85.94)		
No	9 (15.00)	9 (14.06)		
NYHA classification			0.342	0.843
II	15 (25.00)	19 (29.69)		
III	28 (46.67)	28 (43.75)		
IV	17 (28.33)	17 (26.56)		
Types of infectious pathogens				
Gram-negative bacteria	7	6	-	-
Pseudomonas aeruginosa	14	13	-	-
Acinetobacter baumannii	5	8	-	-
Gram-positive bacteria	8	10	-	-
Staphylococcus aureus	10	12	-	-
Streptococcus pneumoniae	18	14	-	-
Other pathogenic bacteria	13	8	-	-

generation cephalosporin, acts on bacteria in lung, skin and soft tissue, inhibits the synthesis of bacterial cell wall and promotes the apoptosis of bacteria [15, 16]. Levofloxacin, as the third generation quinolone antibiotic, exerts its antibacterial effect by inducing bacterial DNA gyrase decomposition [17, 18]. Thus, many clinical studies have confirmed that ceftazidime combined with levofloxacin has better antibacterial effect and lung inflammation relief effect on patients with pulmonary infection [19, 20]. This study analyzed the cardiopulmonary function and immune mechanism of ceftazidime combined with levofloxacin in the treatment of patients with heart failure and pulmonary infection.

Materials and methods

General data

A total of 124 patients with heart failure and pulmonary infection admitted into our hospital from June 2018 to October 2019 were selected and divided into groups according to different treatment schemes. Among them, 60 who were given ceftazidime intravenous drip on the basis of routine treatment were included in group A, and 64 who were given levofloxacin hydrochloride injection based on intravenous drip in group A were included in group B. Patients in group A ranged in age from 50 to 82 years, with an average age of (61.52±4.65) years. While those in group B ranged in age from 50 to 81 years, with an average age of (63.13±4.46) years. Exclusion and inclusion criteria: All the patients in our hospital were those with heart failure and pulmonary infection who were hospitalized for surgery within 12 h, and all of them met the diagnostic criteria of heart failure complicated with pulmonary infection [21]. All cases were excluded from pregnancy, lactation, tumors in other parts of the body, liver and kidney insufficiency or dysfunction, emphysema, pulmonary tuberculosis and other lung-related diseases, as well as incomplete clinical data and loss of follow-up. This study has been approved by the Medical Ethics Committee, and all the subjects have been informed. They all agreed to participate in clinical research, and have signed the full informed consent form (**Table 1**).

Treatment methods and grouping

Patients in groups A and B were given routine treatment such as monitoring vital signs and maintaining electrolyte balance. On the basis of routine treatment, patients in group A were given ceftazidime (Guangdong Bozhou Pharmaceutical Co., Ltd.) 2.0 g + 100 mL 0.9% sodium chloride injection every 12 h.

Patients in group B were given levofloxacin hydrochloride injection (Hunan Kelun Pharmaceutical Co., Ltd.) 4.0 g + 100 mL 0.5% glucose injection every 24 h based on intravenous drip in group A.

Outcome measures

The clinical efficacy of patients after 7 days of medication were compared [22] (the clinical

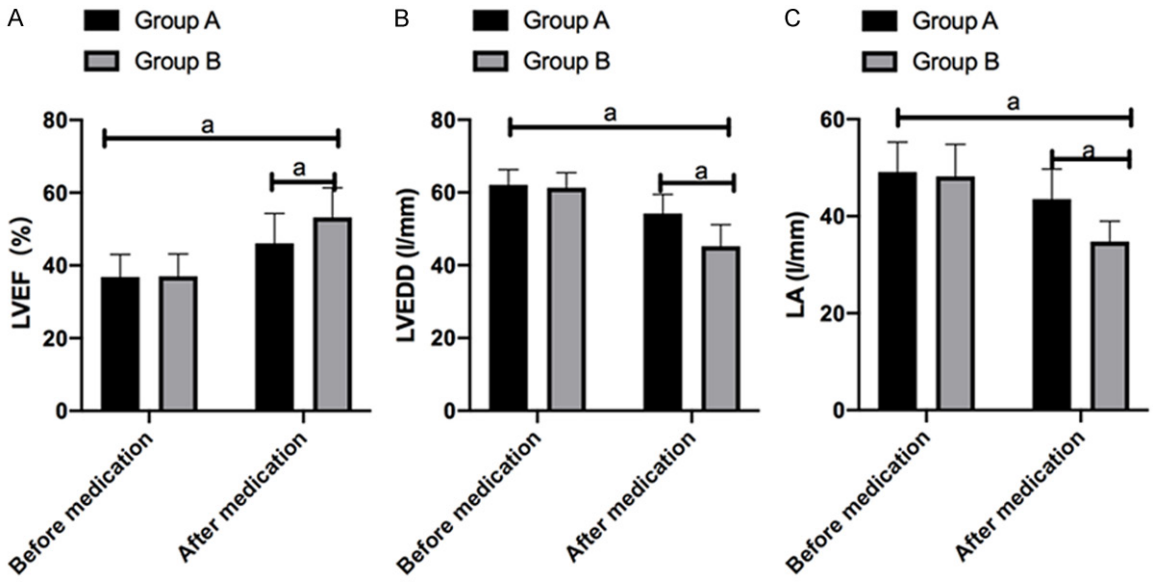

Figure 1. Echocardiogram results. A: LVEF (%) level of patients in groups A and B; B: LVEDD (l/mm) level of patients in groups A and B; C: LA (l/mm) level of patients in groups A and B; a means P<0.05.

efficacy was evaluated as markedly effective, effective and ineffective in view of the international guidelines for the diagnosis and treatment of heart failure; total effective rate = (markedly effective cases + effective cases)/ total cases×100%). The changes of cardiac function were compared [left ventricular ejection fraction (LVEF), left ventricular end diastolic diameter (LVEDD) and left atrial diameter (LA) measured by echocardiogram between both groups. The lung function [the maximum minute ventilation (MMV), total lung capacity (TLC) and forced expiratory volume in 1 second (FEV1)] was measured by MSA99 lung function instrument of Maibang, Beijing. The pathogenic bacteria of patients in both groups before and after treatment were observed. The infection [serum levels of brain natriuretic peptide (BNP), procalcitonin (PCT) and C-reactive protein (CRP)] and immune indexes ($CD3^+$, $CD4^+$, $CD8^+$, $CD4^+/CD8^+$) were compared before and after treatment. The adverse reactions of patients were compared one month after treatment.

Statistical methods

SPSS 20.0 was used for analysis (Shanghai Cabit Information Technology Co., Ltd.). The counting data were assessed by Chi-square test, and the measurement data were analyzed by T test. The comparison before and after treatment was evaluated by paired T test. P<0.05 was statistically remarkable.

Results

General clinical data of patients in groups A and B

Comparing the general clinical data of the two groups of patients, the difference was not statistically significant (P>0.05).

Cardiac function and lung function of patients in groups A and B

(1) Cardiac function of patients in groups A and B: The LVEF, LVEDD and LA levels of patients in both groups were measured by echocardiogram: The levels of LVEDD and LA decreased after treatment compared with those before treatment, but LVEF was up-regulated (P<0.05). The adjustment range of LVEF, LVEDD and LA in group B after treatment was greater than that in group A. (P<0.05) (**Figure 1**).

(2) Lung function of patients in groups A and B: The results showed that the levels of MMV, TLC and FEV1 in both groups were all up-regulated after treatment (P<0.05). In addition, MMV, TLC and FEV1 in group B were increased more than those in group A (P<0.05) (**Figure 2**).

Pathogens of patients in groups A and B before and after treatment

The results of bacterial culture showed that the clearance rate of pathogenic bacteria in group

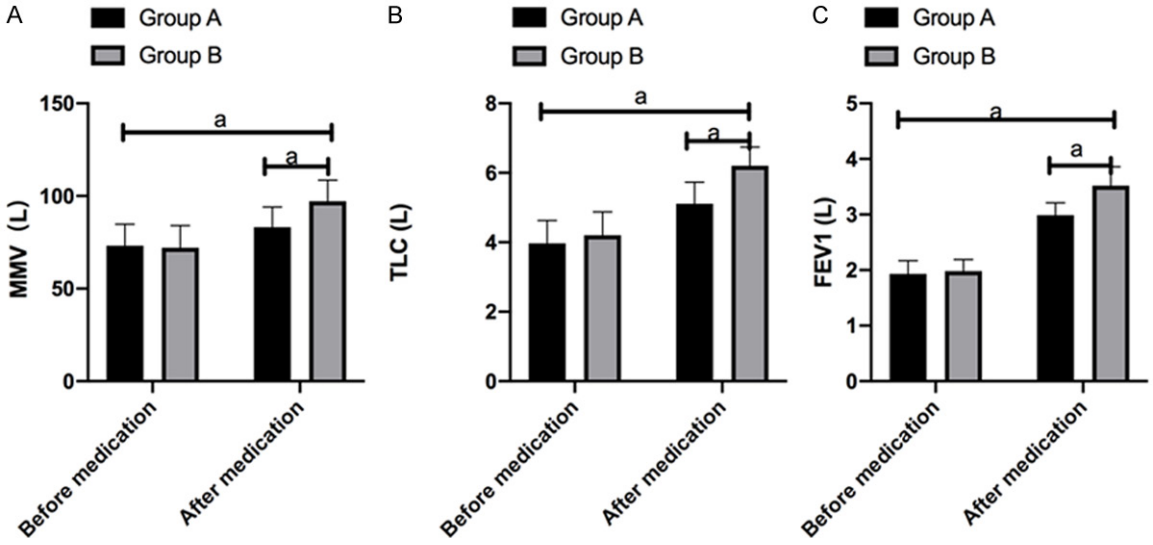

Figure 2. Results of lung function. A: MMV (L) level of patients in groups A and B; B: TLC (L) level of patients in groups A and B; C: FEV1 (L) level of patients in groups A and B; a means P<0.05.

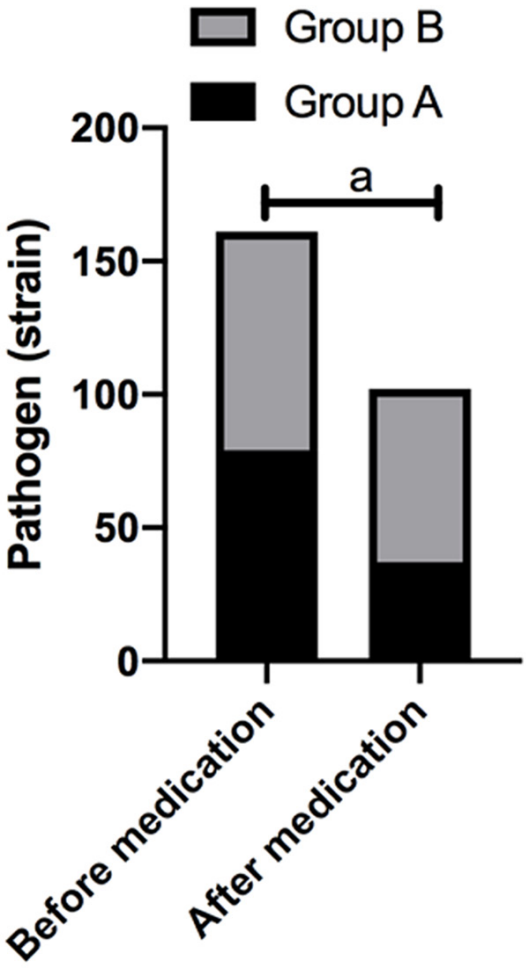

Figure 3. Pathogens. After treatment, the number of pathogenic bacteria in group B was obviously less than that in group A; a means P<0.05.

A was 46.84% (37/79), and that in group B was 79.27% (65/82). The rate of pathogenic bacteria in group B was higher than that in group A (P<0.05) (**Figure 3**).

Levels of infection and immune indexes of patients in groups A and B before and after treatment

(1) Serum infection index level: The levels of BNP, PCT and CRP in patients of both groups were detected: The levels of BNP, PCT and CRP decreased after treatment compared with those before treatment (P<0.05). Furthermore, the down-regulated levels of the three in group B were higher than those in group A after treatment (P<0.05) (**Figure 4**).

(2) Serum immune index level: Serum $CD3^+$, $CD4^+$, $CD8^+$, $CD4^+/CD8^+$ levels were measured by flow cytometry. The results showed that the levels of $CD3^+$, $CD4^+$, $CD4^+/CD8^+$ of patients in groups A and B were higher than those before treatment (P<0.05), while $CD8^+$ decreased. However, after treatment, the levels of serum $CD3^+$, $CD4^+$, $CD4^+/CD8^+$ in group B increased more and $CD8^+$ decreased more, but the difference was not statistically significant (**Figure 5**).

Clinical efficacy and adverse reactions after 7 days of medication

(1) Clinical efficacy: The clinical efficacy of group B after 7 days was 85.00%, which was higher than that of group A (98.44%, P<0.01) (**Table 2**).

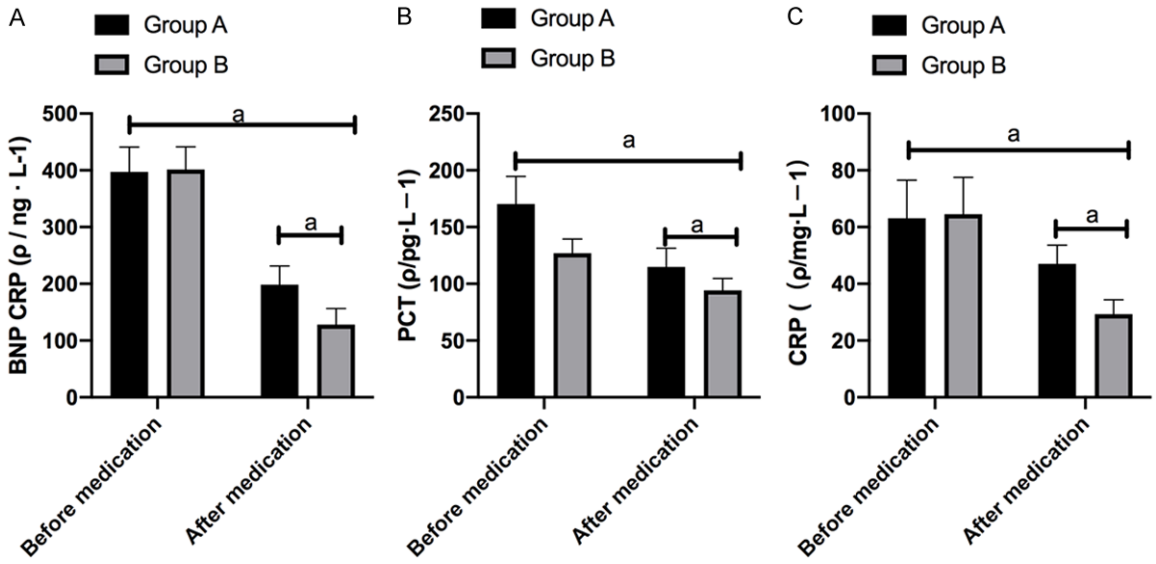

Figure 4. Serum infection indexes. A: BNP, CRP (ρ/ng·L^{-1}) levels of patients in groups A and B; B: PCT (ρ/pg·L^{-1}) levels of patients in groups A and B; C: CRP (ρ/mg·L^{-1}) level of patients in groups A and B; a means P<0.05.

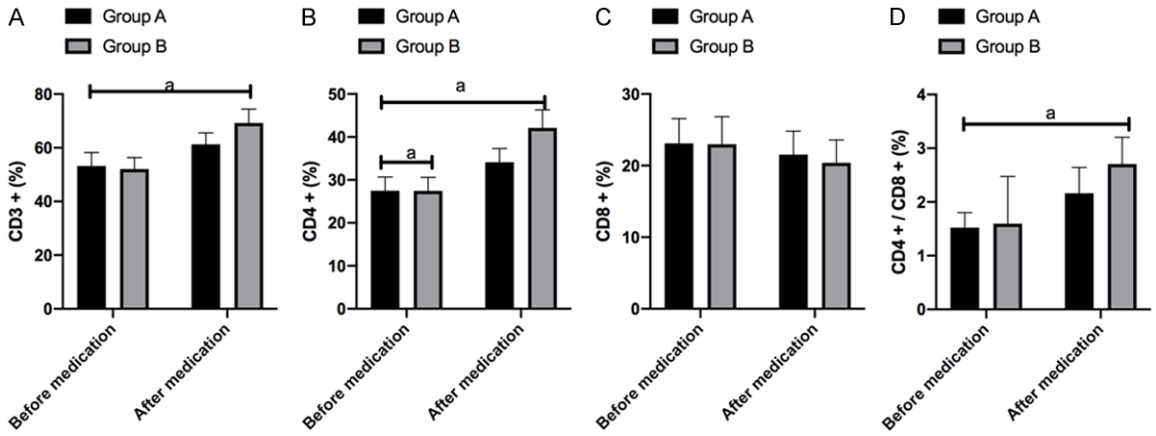

Figure 5. Serum immune index level. A: CD3$^+$ (%) level of patients in groups A and B; B: CD4$^+$ (%) level of patients in groups A and B; C: CD8$^+$ (%) level of patients in groups A and B; D: CD4$^+$/CD8$^+$ (%) level of patients in groups A and B; a means P<0.05.

Table 2. Clinical efficacy

Group	Group A (60)	Group B (64)	X^2	P
Effective	19 (31.67)	20 (31.25)	-	-
Markedly effective	32 (53.33)	43 (68.25)	-	-
Ineffective	9 (15.00)	1 (1.56)	-	-
Total effective rate	51 (85.00)	63 (98.44)	7.542	0.006

(2) Adverse reactions: Patients were followed up for one month, and there was no marked difference in adverse drug reaction rates between both groups (P>0.05) (**Table 3**).

Discussion

Patients with heart failure are often accompanied with various serious complications due to the decrease of cellular immune function [23, 24]. T-lymphocyte subsets can resist infection and play an important role in protecting individual cellular immune function, while low CD8$^+$ level can promote immune balance and stress injury [25, 26]. According to the treatment plan of heart failure complicated with pulmonary infection, this study analyzed

Table 3. Adverse reactions

Group	Group A (60)	Group B (64)	X^2	P
Rash	1 (1.67)	1 (1.56)	-	-
Gastrointestinal discomfort	0 (0.00)	0 (0.00)	-	-
Dizzy	1 (1.67)	0 (0.00)	-	-
Nausea	0 (0.00)	0 (0.00)	-	-
Total rate of adverse reactions	2 (3.34)	1 (1.56)	0.000	1.000

the effect of ceftazidime combined with levofloxacin on cardiopulmonary function and immune mechanism of patients.

The results manifested that the adverse reactions of both groups were similar, and the total adverse rates of rash, gastrointestinal discomfort, dizziness and nausea had little difference. However, the comprehensive clinical efficacy showed that ceftazidime combined with levofloxacin had a better clinical efficacy on heart failure complicated with pulmonary infection than ceftazidime alone. By analyzing the cardiac function and lung function of patients with combined medication and ceftazidime alone, we found that the levels of LVEDD and LA in the cardiac function of patients decreased after treatment. However, after ceftazidime combined with levofloxacin, LVEF, LVEDD and LA fluctuated more. We believe that ceftazidime combined with levofloxacin can improve cardiac function and reduce cardiac load better.

Lung dysfunction is one of the obvious signs in patients with lung infection [27]. With repeated infection, the inflammatory reaction in the lung is aggravated, and the inflammatory secretion will make the lung tissue sticky, forming a vicious circle of sticky sputum-inflammation-increased sticky sputum in lung infection, which aggravates the damage of lung function [28]. The results of bacteriological culture showed that the clearance rate of pathogenic bacteria after ceftazidime combined with levofloxacin was higher than that of ceftazidime alone, and MMV, TLC, FEV1 were increased dramatically, and the recovery of lung function was better. Levofloxacin is a broad-spectrum antibiotic, which regulates the inflammatory secretion of the body by killing bacterial inflammation, thereby reducing the adsorption capacity of mucus in the respiratory tract of patients and inhibiting the vicious circle of lung infection and inflammation to achieve better efficacy treating the disease [29, 30]. Saxena et al. found that levofloxacin reduced the level of inflammatory factors in elderly patients with acute exacerbation of chronic obstructive pulmonary disease complicated with pulmonary infection, decreased the inflammatory stimulus, inhibited the activity of pathogenic bacteria and optimized the lung function [31].

Finally, the levels of serum BNP, PCT, CRP and immune indexes before and after treatment were analyzed. The consumption of heart failure disease itself makes the patient's immune system disorganized, and the immune function of the body decline [32, 33]; It has been reported that pulmonary infection in patients with heart failure can obviously aggravate the immune dysfunction and further aggravate the abnormal situation of organism function [34, 35]. The serum immune indexes measured by flow cytometry showed that the levels of $CD3^+$, $CD4^+$, $CD4^+/CD8^+$ increased and $CD8^+$ decreased after treatment. However, after treatment, the serum $CD3^+$, $CD4^+$, $CD4^+/CD8^+$ levels in group B increased more and $CD8^+$ levels decreased more. A large number of studies have confirmed that levofloxacin has strong penetrability and high concentration in lung, which can improve blood oxygen level and inhibit lung infection at the same time, and optimize the effect of improving patients' immunological indexes [36]. We believe that ceftazidime combined with levofloxacin has a better effect on improving the immune function of T cell subsets. The levels of BNP, PCT and CRP decreased after treatment compared with those before treatment. Furthermore, the down-regulated levels of BNP, PCT and CRP in patients treated by ceftazidime combined with levofloxacin were greater than those in patients treated with ceftazidime alone. Cardiac function and the prognosis of patients with heart failure are assessed by detecting the levels of BNP, PCT and CRP [37]: The increase of heart volume and pressure load in patients with heart failure can lead to enhanced expression of BNP in atrial and ventricular myocytes, which reflects the sensitivity indexes of ventricular function. PCT and CRP are specific indicators of infectious diseases, and PCT is stimulated and secreted during infection; CRP is an acute

phase protein secreted by body tissue injury, which enters the blood circulation of the body [38, 39]. The secretion levels of BNP, PCT and CRP are inversely proportional to the prognosis of patients with heart failure and pulmonary infection [40]. It has been reported that ceftazidime combined with levofloxacin can increase the drug concentration of airway epithelial cells, reduce BNP and relieve the cardiopulmonary function of patients [41]. It is believed that ceftazidime combined with levofloxacin can improve the immune function while optimizing the clinical efficacy and cardiopulmonary function.

There are still some limitations in this study. For instance, the prognosis of ceftazidime combined with levofloxacin in the treatment of patients with heart failure and pulmonary infection is still unclear. Whether it can affect lung-related inflammatory factors through drug pathways needs further investifation.

Acknowledgements

This study is financially supported by E-stablishment of ECV304 cell apoptosis model induced by gp120 and study of its mechanism, Scientific research project approved by Heilongjiang Provincial Health Committee in 2019 2019-253.

Disclosure of conflict of interest

None.

Address correspondence to: Limin Xing, Department of Nursing, Xiangyang No. 1 People's Hospital Affiliated to Hubei University of Medicine, Xiangyang 441000, Hubei Province, China. Tel: +86-13597512067; E-mail: xlm13597512067@163.com; Li Liu, Department of Cardiothoracic Surgery, Xiangyang No. 1 People's Hospital Affiliated to Hubei University of Medicine, No. 15 Jiefang Road, Fancheng District, Xiangyang 441000, Hubei Province, China. Tel: +86-13986399736; E-mail: jason19870912@sina.com

References

[1] Howlett JG, Chan M, Ezekowitz JA, Harkness K, Heckman GA, Kouz S, Leblanc MH, Moe GW, O'Meara E, Abrams H, Ducharme A, Grzeslo A, Hamilton PG, Koshman SL, Lepage S, McDonald M, McKelvie R, Rajda M, Swiggum E, Virani S and Zieroth S; Canadian Cardiovascular Society Heart Failure Guidelines Panels. The Canadian cardiovascular society heart failure companion: bridging guidelines to your practice. Can J Cardiol 2016; 32: 296-310.

[2] Edelmann A, English JD, Chen SJ and Kasper FK. Analysis of the thickness of 3-dimensional-printed orthodontic aligners. Am J Orthod Dentofacial Orthop 2020; 158: e91-e98.

[3] Savarese G and Cosentino F. The interaction between dapagliflozin and blood pressure in heart failure: new evidence dissipating concerns. Eur Heart J 2020; 41: 3419-3420.

[4] Stone GW, Weissman NJ and Mack MJ; COAPT Investigators. Transcatheter mitral-valve repair in patients with heart failure. Reply. N Engl J Med 2019; 380: 1980-1981.

[5] Kalam A, Al-Sehemi AG, Alrumman S, Du G, Pannipara M, Assiri M, Almalki H and Moustafa MF. Colorimetric sensing of toxic metal and antibacterial studies by using bioextract synthesized silver nanoparticles. J Fluoresc 2017; 27: 2045-2050.

[6] Liu ZP, Zhang Y, Bian H, He XR, Zhou YJ, Wang LJ and Ding N. Clinical application of rapid B-line score with lung ultrasonography in differentiating between pulmonary infection and pulmonary infection with acute left ventricular heart failure. Am J Emerg Med 2016; 34: 278-281.

[7] Kadoglou NPE, Bracke F, Simmers T, Tsiodras S and Parissis J. Influenza infection and heart failure-vaccination may change heart failure prognosis? Heart Fail Rev 2017; 22: 329-336.

[8] Kokkoris S, Papachatzakis I, Gavrielatou E, Ntaidou T, Ischaki E, Malachias S, Vrettou C, Nichlos C, Kanavou A, Zervakis D, Perivolioti E, Ranellou K, Argyropoulou A, Zakynthinos S, Kotanidou A and Routsi C. ICU-acquired blood stream infections in critically ill patients with coronavirus disease-19. J Hosp Infect 2021; 107: 95-97.

[9] Nam KH, Koh Y, Lim CM, Huh JW, Jung SH, Kang PJ, Lim JY and Hong SB. Central extracorporeal membrane oxygenation for bridging of right-sided heart failure to lung transplantation: a single-center experience and literature review. J Cardiothorac Vasc Anesth 2019; 33: 1873-1876.

[10] Nakade T, Adachi H, Murata M and Naito S. Poor increase in pulse pressure during cardiopulmonary exercise testing predicts cardiovascular death of patients with heart failure with reduced ejection fraction. Circ J 2020; 84: 1519-1527.

[11] Imamura T, Kinugawa K, Ono M, Fukushima N, Shiose A, Matsui Y, Yamazaki K, Saiki Y, Matsumiya G, Arai H and Sawa Y. Bridge-to-bridge left ventricular assist device implantation strategy vs. primary left ventricular assist device implantation strategy. Circ J 2020; 84: 2198-2204.

[12] Pan Z, Liu R, Zhang P, Zhou H, Fu Y and Zhou J. Combination of tigecycline and levofloxacin for successful treatment of nosocomial pneumonia caused by new delhi metallo-beta-lactamase-1-producing raoultella planticola. Microb Drug Resist 2017; 23: 127-131.
[13] Heffernan AJ, Sime FB, Lipman J, Dhanani J, Andrews K, Ellwood D, Grimwood K and Roberts JA. Intrapulmonary pharmacokinetics of antibiotics used to treat nosocomial pneumonia caused by Gram-negative bacilli: a systematic review. Int J Antimicrob Agents 2019; 53: 234-245.
[14] Chirakul S, Somprasong N, Norris MH, Wuthiekanun V, Chantratita N, Tuanyok A and Schweizer HP. Burkholderia pseudomallei acquired ceftazidime resistance due to gene duplication and amplification. Int J Antimicrob Agents 2019; 53: 582-588.
[15] Gottig S, Frank D, Mungo E, Nolte A, Hogardt M, Besier S and Wichelhaus TA. Emergence of ceftazidime/avibactam resistance in KPC-3-producing Klebsiella pneumoniae in vivo. J Antimicrob Chemother 2019; 74: 3211-3216.
[16] Ortiz de la Rosa JM, Nordmann P and Poirel L. ESBLs and resistance to ceftazidime/avibactam and ceftolozane/tazobactam combinations in Escherichia coli and Pseudomonas aeruginosa. J Antimicrob Chemother 2019; 74: 1934-1939.
[17] Zusso M, Lunardi V, Franceschini D, Pagetta A, Lo R, Stifani S, Frigo AC, Giusti P and Moro S. Ciprofloxacin and levofloxacin attenuate microglia inflammatory response via TLR4/NF-kB pathway. J Neuroinflammation 2019; 16: 148.
[18] Nishikubo M, Kanamori M and Nishioka H. Levofloxacin-associated neurotoxicity in a patient with a high concentration of levofloxacin in the blood and cerebrospinal fluid. Antibiotics (Basel) 2019; 8: 78.
[19] Zhao L, Li X, He X and Jian L. Levofloxacin-ceftazidime administration regimens combat Pseudomonas aeruginosa in the hollow-fiber infection model simulating abnormal renal function in critically ill patients. BMC Pharmacol Toxicol 2020; 21: 20.
[20] Cadour F, Gust L, Daviet F, Zieleskiewicz L, Dutau H and Scemama U. Combined management of a bronchial artery fistula after lung transplantation. Ann Thorac Surg 2020; 109: e99-e101.
[21] Ozdemir M; European Society of Cardiology. 2014 European Society of Cardiology guidelines on hypertrophic cardiomyopathy. Turk Kardiyol Dern Ars 2014; 42: 693-697.
[22] Marra AM, Benjamin N, Cittadini A, Bossone E and Grunig E. When pulmonary hypertension complicates heart failure. Heart Fail Clin 2020; 16: 53-60.
[23] Wang N, Hales S and Tofler G. 15-year trends in patients hospitalised with heart failure and enrolled in an australian heart failure management program. Heart Lung Circ 2019; 28: 1646-1654.
[24] Latus H, Apitz C, Schmidt D, Jux C, Mueller M, Bauer J, Akintuerk H, Schneider M and Schranz D. Potts shunt and atrial septostomy in pulmonary hypertension caused by left ventricular disease. Ann Thorac Surg 2013; 96: 317-319.
[25] Casey R, Neumann HPH and Maher ER. Genetic stratification of inherited and sporadic phaeochromocytoma and paraganglioma: implications for precision medicine. Hum Mol Genet 2020; 29: R128-R137.
[26] Falsey AR, Walsh EE, Esser MT, Shoemaker K, Yu L and Griffin MP. Respiratory syncytial virus-associated illness in adults with advanced chronic obstructive pulmonary disease and/or congestive heart failure. J Med Virol 2019; 91: 65-71.
[27] Yang L, Yan S, Zhang Y, Hu X, Guo Q, Yuan Y and Zhang J. Novel enzyme formulations for improved pharmacokinetic properties and anti-inflammatory efficacies. Int J Pharm 2018; 537: 268-277.
[28] Seibel J, Kryshen K, Pongracz JE and Lehner MD. In vivo and in vitro investigation of anti-inflammatory and mucus-regulatory activities of a fixed combination of thyme and primula extracts. Pulm Pharmacol Ther 2018; 51: 10-17.
[29] Silindir-Gunay M and Ozer AY. (99m)Tc-radiolabeled Levofloxacin and micelles as infection and inflammation imaging agents. J Drug Deliv Sci Technol 2020; 56: 101571.
[30] Accorinti M, Colao L, Gilardi M, Cecere M, Salotti A and Pesci FR. Levofloxacin and tobramycin for severe bacterial keratouveitis. Ocul Immunol Inflamm 2016; 24: 482-488.
[31] Kuwal A, Joshi V, Dutt N, Singh S, Agarwal KC and Purohit G. A prospective study of bacteriological etiology in hospitalized acute exacerbation of COPD patients: relationship with lung function and respiratory failure. Turk Thorac J 2018; 19: 19-27.
[32] Saito T, Miyagawa K, Chen SY, Tamosiuniene R, Wang L, Sharpe O, Samayoa E, Harada D, Moonen JAJ, Cao A, Chen PI, Hennigs JK, Gu M, Li CG, Leib RD, Li D, Adams CM, Del Rosario PA, Bill M, Haddad F, Montoya JG, Robinson WH, Fantl WJ, Nolan GP, Zamanian RT, Nicolls MR, Chiu CY, Ariza ME and Rabinovitch M. Upregulation of human endogenous retrovirus-K is linked to immunity and inflammation in pulmonary arterial hypertension. Circulation 2017; 136: 1920-1935.
[33] Howrylak JA and Nakahira K. Inflammasomes: key mediators of lung immunity. Annu Rev Physiol 2017; 79: 471-494.

[34] Dureau P, Bougle A, Melac AT, Ait Hamou N, Arbelot C, Ben Hassen K, Charfeddine A, Deransy R, Arcile G, Rouby JJ, Granger B and Amour J. Colour Doppler ultrasound after major cardiac surgery improves diagnostic accuracy of the pulmonary infection score in acute respiratory failure: a prospective observational study. Eur J Anaesthesiol 2019; 36: 676-682.

[35] Nilsson JF, Castellani LG, Draghi WO, Mogro EG, Wibberg D, Winkler A, Hansen LH, Schluter A, Puhler A, Kalinowski J, Torres Tejerizo GA and Pistorio M. Global transcriptome analysis of Rhizobium favelukesii LPU83 in response to acid stress. FEMS Microbiol Ecol 2020; fiaa235.

[36] Soucy AM, Hurteau GJ and Metzger DW. Live vaccination generates both disease tolerance and host resistance during chronic pulmonary infection with highly virulent francisella tularensis SchuS4. J Infect Dis 2018; 218: 1802-1812.

[37] Ikegami H, Yamasaki K, Kawanami T, Fukuda K, Akata K, Nakamura M, Ikushima I, Fukuda Y, Noguchi S and Yatera K. Pulmonary mycobacterium parascrofulaceum infection in a patient with chronic progressive pulmonary aspergillosis: a case report and literature review. Intern Med 2020; 59: 1417-1422.

[38] Demissei BG, Cleland JG, O'Connor CM, Metra M, Ponikowski P, Teerlink JR, Davison B, Givertz MM, Bloomfield DM, Dittrich H, van Veldhuisen DJ, Hillege HL, Voors AA and Cotter G. Procalcitonin-based indication of bacterial infection identifies high risk acute heart failure patients. Int J Cardiol 2016; 204: 164-171.

[39] Zhang Y, Luo Y, Nijiatijiang G, Balati K, Tuerdi Y and Liu L. Correlations of changes in brain natriuretic peptide (BNP) and cardiac troponin I (cTnI) with levels of C-reactive protein (CRP) and TNF-alpha in pediatric patients with sepsis. Med Sci Monit 2019; 25: 2561-2566.

[40] Wang T, Hou Y and Wang R. A case report of community-acquired Pseudomonas aeruginosa pneumonia complicated with MODS in a previously healthy patient and related literature review. BMC Infect Dis 2019; 19: 130.

[41] Poulin S, Corbeil C, Nguyen M, St-Denis A, Cote L, Le Deist F and Carignan A. Fatal Mycobacterium colombiense/cytomegalovirus coinfection associated with acquired immunodeficiency due to autoantibodies against interferon gamma: a case report. BMC Infect Dis 2013; 13: 24.