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Original Article

Effects of His bundle pacing and right ventricular apex pacing on cardiac electrical and mechanical synchrony and cardiac function in patients with heart failure and atrial fibrillation

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Abstract: Objective: To investigate the effects of right ventricular apex pacing and His bundle pacing on cardiac mechanical and electrical synchrony and cardiac function in patients with heart failure and atrial fibrillation. Methods: A total of 72 patients with heart failure and atrial fibrillation who received permanent pacemaker implantation in our hospital were randomly divided into two groups, with 36 patients in each group. The control group received the right ventricular apex pacing, and the study group received His bundle pacing. In the two groups, the pacing parameters, cardiac function, cardiac electricity, mechanical synchrony, complications and living quality were compared. Results: During operation and 12 months after the operation, the study group's pacing threshold was higher than the pacing threshold of the control group (all P<0.001). Compared with that before the procedure, NYHA grade and LVEDD of the two groups 12 months after operation were decreased (all P<0.001), while LVEF and various quality of life scores were increased (all P<0.001). The study group's NYHA grade and LVEDD were lower than those of the control group 12 months after operation (all P<0.001), while the study group's quality of life scores and LVEF were higher than those of the control group (all P<0.001). Twelve months after operation, the study group's QRS width and IVMD were lower than QRS width and IVMD of the control group (all P<0.001). The study group's complication rate was 5.56% (2/36), which was lower than the control group's complication rate (22.22% (8/36), P<0.05). Conclusion: Compared with right ventricular apical pacing, His bundle pacing in the treatment of heart failure with atrial fibrillation can better maintain the cardiac electrical and mechanical synchronization, promote the recovery of cardiac function, improve living quality, and has fewer complications and significant advantages.

Keywords: Heart failure with atrial fibrillation, right ventricular apical pacing, His bundle pacing, cardiac function, complications

Introduction

Heart failure is a common cardiovascular disease. The clinical manifestations of heart failure include dyspnea, shortness of breath after activities, and fatigue, which seriously endangers human health [1]. It has been shown that, about 30%-40% of patients with heart failure are complicated with atrial fibrillation [2]. Atrial fibrillation is a kind of common arrhythmia that can promote each other with heart failure, aggravate the patient's condition and increase treatment difficulty. At present, right ventricular apex pacing is a routine treatment for patients with heart failure and atrial fibrillation, which can effectively relieve the clinical symptoms and improve quality of life [3, 4]. Studies have shown that, some patients with right ventricular apical pacing still have a continuous decline in cardiac function after treatment, and need to be re-hospitalized [5]. This kind of patient usually has a poor prognosis. Therefore, treating heart failure with atrial fibrillation and improving the cardiac function of patients is a thorny problem faced by clinicians.

In recent years, His bundle pacing has been gradually used in the clinical treatment of patients with atrial fibrillation and heart failure, which simulates normal ventricular activation and conduction to improve patients' cardiac function [6]. His bundle pacing used in treating

patients suffering from heart failure and atrial fibrillation can significantly enhance the clinical effect [7]. However, it is challenging to locate and fix the electrodes in His bundle pacing, which has the potential to damage and block His bundle. There are relatively few clinical reports on using His bundle pacing for treating heart failure with atrial fibrillation [8]. Given this, this study explored the effects of His bundle pacing and right ventricular apical pacing on cardiac electrical and mechanical properties in patients with heart failure and atrial fibrillation. The aim of this study is to provide a reference for the clinical treatment of patients with above-mentioned diseases.

Materials and methods

General data

With the approval of the Medical Ethics Committee of Xiangyang No. 1 People's Hospital, Hubei University of Medicine, 72 patients with heart failure and atrial fibrillation who received permanent pacemaker implantation from March 2017 to October 2019 were chosen as the research objects, including 42 male patients and 30 female patients with an average age of (59.0±3.4) years old. Seventy-two patients were grouped into two randomly with 36 cases in each group. Inclusion criteria: people aged between 40 and 80; those who meet the relevant diagnostic criteria in Chinese guidelines for diagnosis and treatment of heart failure and guidelines for primary diagnosis and treatment of atrial fibrillation, and meet the indications for permanent pacemakers [9, 10]; patients who signed the informed consent voluntarily; patients whose cardiac function (NYHA) grade was II-III; patients who have good compliance and cooperate with the researchers. Exclusion criteria: patients with severe heart valve disease; patients who received cardiac resynchronization therapy; patients with unstable angina pectoris and acute myocardial infarction; patients with expected survival time less than 12 months.

Treatment

Control group: Right ventricular apical pacing was performed in the control group [11]. Venipuncture was carried out under the left clavicle, and a guidewire was introduced to dilate the sheath tube to the right atrium. The active fixed electrode was used to implant the right atrial and right ventricular leads into the right auricle and right ventricular apex. The atrioventricular interval (> PR interval) and AAIR mode were set.

Study group: The study group was given His bundle pacing therapy [12]. The axillary vein puncture was selected, and the C304 His sheath was sent to the right ventricle or right atrium. The sheath tube was washed with heparin saline, and the lead was sent (the electrode was exposed at the head end), and the sheath tube was adjusted to be close to the anterior septum of the tricuspid valve ring. Under X-ray fluoroscopy, the position of sheath tube and lead was changed to the larger His bundle. His potential, pacing QRS waveform and QRS waveform were compared to determine whether the localization was successful. After positioning, the lead was fixed and rotated clockwise for 5-6 turns. After fixation, the delivery sheath was withdrawn to the high right atrium. The lead tension was adjusted and pacing parameters were measured.

Outcome measures

Primary outcome measures: (1) Pacing parameters: Patients enrolled in this study were followed up for 12 months. The pacing parameters 12 months after and during operation were compared between the two groups, including R wave amplitude, pacing threshold and electrode impedance.

(2) Cardiac function: Cardiac function was compared between the two groups before and 12 months after the operation, including NYHA grade, left ventricular ejection fraction (LVEF) and left ventricular end-diastolic diameter (LVEDD).

(3) Cardiac electrical and mechanical synchrony: Cardiac electrical and mechanical synchrony were compared between the two groups 12 months after the operation, including QRS width, atrioventricular synchrony parameter (LVFT/R-R), ventricular mechanical delay time (IVMD), and time standard deviation of peak systolic velocity (Ts-SD) in 12 segments of the left ventricular myocardium. Color Doppler ultrasound was used for examination.

Secondary outcome measures: (1) Complications: Complications including hemopneumothorax, pericardial effusion, catheter electrode displacement, etc. in the two groups were compared.

Table 1. Comparison of baseline data between the two groups (n, $\bar{x} \pm sd$)

Groups	Control group (n=36)	Study group (n=36)	χ^2/t	P
Gender (male/female)	19/17	23/13	0.914	0.339
Age (year)	58.7±3.3	59.1±3.6	0.545	0.588
Course of disease (year)	7.7±1.6	7.4±1.8	0.660	0.511
Comorbidities (hypertension/diabetes/others)	17/12/11	18/14/9	0.128	0.815
NYHA classification (II/III)	15/21	17/19	0.225	0.635

Table 2. Comparison of pacing parameters during and 12 months after operation ($\bar{x} \pm sd$)

Indicators	Control group (n=36)	Study group (n=36)	t	P
R wave amplitude (mV)				
During operation	8.24±1.67	8.35±1.53	0.291	0.772
12 months after operation	8.34±1.88	8.32±1.65	0.048	0.962
Pacing threshold (V)				
During operation	0.81±0.41	1.45±0.52	5.799	0.000
12 months after operation	0.78±0.43	1.42±0.61	5.145	0.000
Electrode impedance (Ω)				
During operation	645.36±125.21	643.18±133.52	0.072	0.943
12 months after operation	651.25±138.25	648.36±146.32	0.086	0.932

(2) The quality of life: In the two groups, changes in living quality were compared before and 12 months after the operation. SF-36 quality of life scale was referred to and a questionnaire was designed to evaluate the quality of life of patients, including physiological function, psychological function, social relationship and physical pain. The total score of each aspect was 0-50. The higher the score is, the better the quality of life is.

Statistical methods

SPSS 22.0 software was used to process the research data, and the measurement data was represented by ($\bar{x} \pm sd$). Independent sample t-test and paired sample t-test were used for inter-group and intra-group comparison, respectively. The count data was expressed by percentage, and the chi-square test was used. The difference was statistically significant when $P<0.05$.

Results

Baseline data

There was no significant difference in gender, age, course of the disease, comorbid diseases and NYHA classification between the two groups (all $P>0.05$). It can be seen that the baseline data of the two groups are comparable. See **Table 1**.

Pacing parameters

Compared with intraoperative pacing parameters, there were no significant changes in pacing parameters at 12 months after operation between the two groups (all $P>0.05$). The study group's pacing threshold was higher than the control group's pacing threshold during and 12 months after procedure (all $P<0.001$). Between the two groups, there was no significant difference in pacing R wave amplitude and electrode impedance during and 12 months after operation (all $P>0.05$). It can be seen that His bundle pacing has a higher pacing threshold in the treatment of patients suffering from heart failure and atrial fibrillation. See **Table 2** and **Figure 1**.

Cardiac function

NYHA grade and LVEDD of the two groups were decreased 12 months after operation (all $P<0.001$) compared with those before the operation, while LVEF were increased (all $P<0.001$). NYHA grade and LVEDD of the study group were lower than those of the control group 12 months after operation (all $P<0.001$), while LVEF was higher than the control group's LVEF

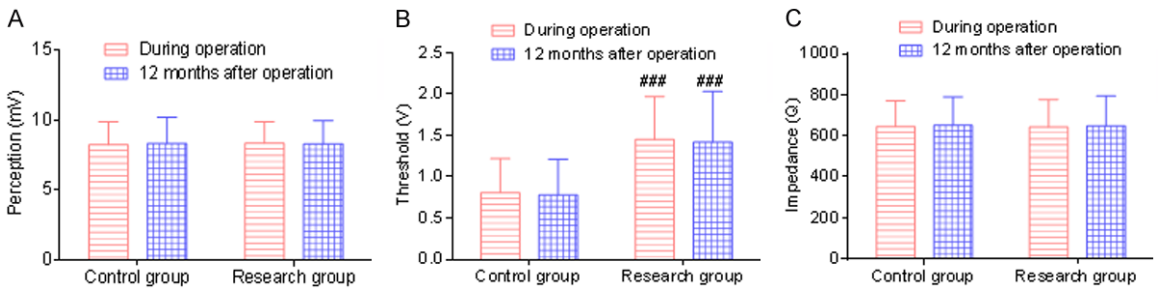

Figure 1. Comparison of pacing parameters between the two groups during and 12 months after operation. A: R wave amplitude; B: Pacing threshold; C: Electrode impedance. Compared with the control group, ###P<0.001.

Table 3. Comparison of cardiac function between the two groups before and 12 months after operation ($\bar{x} \pm sd$)

Indicators	Control group (n=36)	Study group (n=36)	t	P
NYHA classification (grade)				
Before operation	2.58±0.35	2.47±0.38	1.228	0.206
12 months after operation	2.03±0.34***	1.57±0.26***	6.448	0.000
LVEF (%)				
Before operation	35.29±2.12	35.18±2.09	0.222	0.825
12 months after operation	39.57±2.27***	45.37±2.31***	10.745	0.000
LVEDD (mm)				
Before operation	58.96±2.24	58.89±2.18	0.134	0.894
12 months after operation	55.28±2.05***	51.47±2.12***	7.752	0.000

Note: Compared with that before operation in this group, ***P<0.001. LVEF, left ventricular ejection fraction; LVEDD, left ventricular end- diastolic diameter.

(P<0.001). It can be seen that His bundle pacing in the treatment of heart failure with atrial fibrillation can effectively improve the cardiac function of patients. See **Table 3** and **Figure 2**.

Cardiac electrical and mechanical synchrony

The study group's QRS width and IVMD were lower than the control group's QRS width and IVMD (all P<0.001) 12 months after the operation, while LVFT/R-R and Ts-SD of the two groups had no significant difference (P>0.05). It can be seen that His bundle pacing in the treatment of heart failure with atrial fibrillation can better maintain the electrical and mechanical synchronization of the heart. See **Table 4** and **Figure 3**.

Complications

The incidence of complications in the study group was 5.56% (2/36), which was lower than 22.22% (8/36) in the control group (P<0.05). There are fewer complications in treating heart failure with atrial fibrillation by His bundle pacing. See **Table 5**.

Living quality

The two groups' quality of life scores increased 12 months after operation (all P<0.001) compared with that before the operation. And the study group's living quality was higher than the control group's living quality (all P<0.001). It can be seen that His bundle pacing can effectively improve the quality of life of patients with heart failure and atrial fibrillation. See **Table 6**.

Discussion

In recent years, the incidence of heart failure with atrial fibrillation is increasing in China, which brings a heavy burden to the family and society. Right ventricular apex pacing is usually adopted clinically in the treatment of heart failure with atrial fibrillation. Although right ventricular apex pacing has a certain effect, it may lead to ventricular activation and contraction sequence changes. It may not maintain cardiac electrical and mechanical synchronization, resulting in myocardial cell arrangement disorder and even fibrosis. It may also affect the heart function of patients [13]. Electrodes stimulate His bundle. The right ventricle is activated sequentially through His bundle Purkinje system, which can effectively maintain the cardiac electrical and mechanical synchronization to promote cardiac function improvement [14]. Therefore, this study gives heart failure patients

Figure 2. Comparison of cardiac function between the two groups before and 12 months after operation. A: NYHA classification; B: Left ventricular ejection fraction (LVEF); C: Left ventricular end diastolic diameter (LVEDD). Compared with that before operation in this group, ***P<0.001; compared with that in the control group, ###P<0.001.

Table 4. Comparison of cardiac electrical and mechanical synchrony between the two groups 12 months after operation ($\bar{x} \pm s$)

Groups	QRS width (ms)	LVFT/R-R (%)	IVMD (ms)	Ts-SD (ms)
Control group (n=36)	132.25±21.25	45.36±3.29	21.58±3.62	32.51±2.95
Study group (n=36)	115.05±18.96	44.57±3.48	6.37±2.06	20.85±2.57
t	4.834	0.990	21.911	17.881
P	0.000	0.326	0.000	0.815

Note: LVFT/R-R, atrioventricular synchrony parameter; IVMD, ventricular mechanical delay time; Ts-SD, time standard deviation of peak systolic velocity.

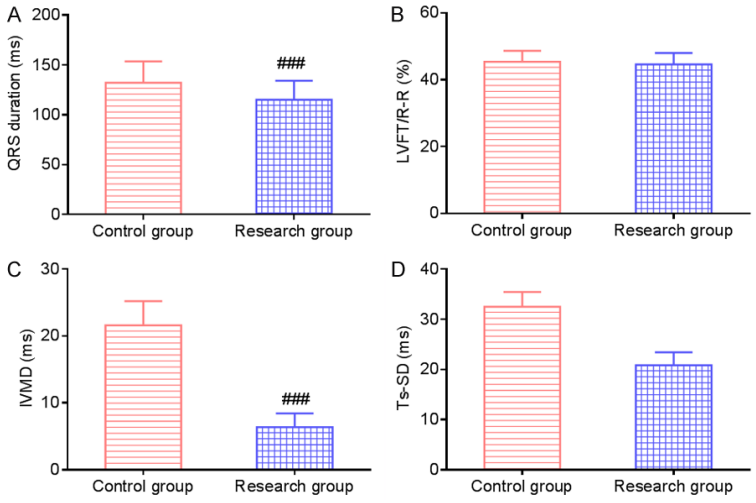

Figure 3. The ratio of cardiac electrical and mechanical synchrony between the two groups 12 months after operation. A: QRS width; B: Atrioventricular synchrony parameter (LVFT/R-R); C: Inter-ventricular mechanical delay time (IVMD); D: Time standard deviation of peak systolic velocity (Ts-SD) in 12 segments of left ventricular myocardium. Compared with the control group, ###P<0.001.

with atrial fibrillation His bundle pacing therapy and improves the patient's heart function and quality of life by maintaining the hearts' electrical and mechanical synchronization.

In this study, the study group's pacing threshold was higher than that of the control group during and 12 months after the operation. Ye et al. have shown that His bundle initiation has a higher pacing threshold, which is significantly higher than right ventricular apex pacing, which is consistent with the results of this study [15]. It is suggested that the higher pacing threshold of His bundle can effectively improve the ventricular rate of patients complicated with heart failure and atrial fibrillation and then improve the cardiac function.

Some studies have found that adequate maintenance of cardiac electrical and mechanical synchronization is the key to obtaining better clinical efficacy in treating heart failure with atrial fibrillation [16]. The results showed that the QRS width, IVMD and Ts-SD of the study group were lower than those of the control group 12 months after the operation. This indicated that there is electrical and mechanical asynchrony in right ventricular apical pacing, which affects the therapeutic effect. The reason is that the left and right ventricles

Table 5. Comparison of complications between the two groups (n (%))

Groups	Hemopneumothorax	Pericardial effusion	Catheter electrode displacement	Total
Control group (n=36)	2 (5.56)	3 (8.33)	3 (8.33)	8 (22.22)
Study group (n=36)	0 (0.00)	1 (2.78)	1 (2.78)	2 (5.56)
χ^2/t	0.514	0.265	0.265	4.181
P	0.473	0.607	0.607	0.041

Table 6. Comparison of quality of life between the two groups before and 12 months after operation ($\bar{x}$ ± sd, points)

Indicators	Control group (n=36)	Study group (n=36)	t	P
Physiological function				
Before operation	33.25±2.36	33.39±2.42	0.249	0.805
12 months after operation	37.50±2.47***	41.02±2.58***	5.913	0.000
Psychological function				
Before operation	34.18±2.63	34.37±2.81	0.296	0.768
12 months after operation	39.42±2.72***	43.05±2.92***	4.458	0.000
Social relations				
Before operation	35.03±2.19	34.87±2.32	0.310	0.764
12 months after operation	39.06±2.51***	44.17±2.84***	8.089	0.000
Physical pain				
Before operation	34.85±2.61	34.57±2.58	0.458	0.649
12 months after operation	40.25±3.06***	44.56±2.72***	6.316	0.000

Note: Compared with that before operation in this group, ***P<0.001.

cannot receive electrical signals simultaneously during right ventricular apical pacing. Then ventricular depolarization block occurs, leading to ventricular motor dysfunction [17]. In contrast, His bundle pacing is to locate the electrode in His bundle, which can conduct left and right ventricles at the same time to maintain the electrical and mechanical synchronization of the heart [18, 19]. How to effectively improve patients' heart function with heart failure and atrial fibrillation is the focus of research in major hospitals. Nadine et al. have found that cardiac function improvement in patients with heart failure and atrial fibrillation treated with His bundle pacing is significantly better than that of right ventricular apex pacing [20]. This study showed that NYHA grade and LVEDD decreased, but LVEF increased in the two groups 12 months after operation compared with those before the operation. NYHA grade and LVEDD of the study group were lower than those of the control group, while LVEF was higher than that of control group. It is suggested that His bundle pacing can effectively improve cardiac function in patients with heart failure and atrial fibrillation. The reason may be related to the fact that His bundle pacing can better maintain the electrical and mechanical synchronization of the heart [21, 22].

In this study, the follow-up observation of patients with heart failure and atrial fibrillation found that the score of quality of life in the two groups increased 12 months after operation compared with that before operation, and the score of quality of life in the study group was higher than that in the control group. And the incidence of complications was lower than that of the control group, which is also consistent with the results of Vijaya Raman P [23]. It is suggested that the cardiac function of patients with heart failure and atrial fibrillation can be improved significantly by using His bundle pacing therapy. The complications are less, thus effectively improving the quality of life. Although the effect of His bundle pacing in the treatment of heart failure with atrial fibrillation is accurate, the wire needs to be accurately fixed in the area of His bundle during the operation, which is challenging to achieve. The operation requires high clinical experience and technical requirements of the operator [24]. In addition, the atrioventricular position is relatively special, and the operation may cause atrial capture and reduced ventricular perception [25].

There are still some limitations in this study, such as a small number of samples, short observation time, and no observation of long-term survival of patients. In the future, the number of pieces can be increased and the study time can be extended to explore further the long-term survival of patients with heart failure and atrial fibrillation.

In conclusion, compared with right ventricular apical pacing, the treatment of His bundle pacing in patients with heart failure and atrial fibrillation can better maintain the cardiac electrical and mechanical synchronization, promote the recovery of cardiac function, improve the quality of life, and has fewer complications, which has clinical significance.

Disclosure of conflict of interest

None.

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