

## Original Article

# The role of a heart rhythm monitoring APP in monitoring atrial fibrillation after pacemaker implantation during COVID-19

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**Abstract:** Background: Atrial fibrillation is the main cause of cardiogenic stroke and a common long-term complication after pacemaker implantation. Early detection and early treatment of atrial fibrillation after pacemaker implantation can reduce the incidence of cardiogenic stroke. In the period of the novel coronavirus epidemic, tele-medicine and monitoring has become a new diagnosis tool and treatment mode for chronic disease. Methods: From January 2020 to January 2021, a total of 1985 patients with pacemaker implantation in the Affiliated Hospital of Guangdong Medical University from January 2000 to January 2017 were screened, among which 825 patients with DDD/DDDR and AAI/AAIR were recruited, and 278 of them were enrolled in this observational study. The patients were randomly divided into two groups: settling monitoring group and control group. Atrial fibrillation was detected by rhythm monitoring APP and pacemaker program controller. Results: The incidence of atrial fibrillation was 11.5% (n=16) in the pacemaker monitoring group and 9.4% (n=13) in the control group, and there was no significant difference between the two groups (P>0.05). The sensitivity and specificity of rhythm monitoring APP for detecting atrial fibrillation were 81.3% and 95.3%, respectively. The positive predictive value of atrial fibrillation detected by rhythm monitoring APP (Anton) was 68.4% and the negative predictive value was 97.6%. The area under ROC curve of cardiac rhythm monitoring APP (Anton) was 0.856, 95% confidence interval: 0.827-0.881, P<0.01. Conclusions: The Rhythm Monitoring APP (Anton) can be used remotely to monitor atrial fibrillation after pacemaker implantation. During the novel coronavirus epidemic, the number of people going to hospitals can be reduced and thus the chance of novel coronavirus infection can be reduced.

**Keywords:** Cardiac rhythm monitoring APP, artificial cardiac pacemaker, COVID-19

## Introduction

A permanent artificial cardiac pacemaker is an effective treatment for bradyarrhythmia and has been used in clinical practice for decades. The long-term complications of permanent artificial cardiac pacemaker implantation are mainly atrial fibrillation, atrial fibrillation related ischemic stroke and heart failure [1, 2]. Early detection and treatment of AF are beneficial to reduce atrial fibrillation associated ischemic stroke and heart failure. The programmed follow-up after pacemaker implantation can detect high-frequency cardiac events and diag-

nose atrial fibrillation by endocardiogram. After implantation of pacemaker, patients may not be able to adhere to an outpatient programmed follow-up due to various reasons, and may have persistent atrial fibrillation or even atrial fibrillation related ischemic stroke or heart failure before pacemaker programming. With the development of artificial intelligence technology, remote diagnosis and monitoring has been widely used in clinical practice and achieved good results. Cardiac rhythm monitoring APP (Anton) is a watch with functions of heart rate, rhythm and blood pressure monitoring. The purpose of this study was to explore whether the

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**Table 1.** General information and follow-up characteristic information

	Anton monitoring group (n=139)	Control group (n=139)	P value
Male (n=170)	87 (62.6%)	83 (59.7)	>0.05
Female (n=108)	52 (37.4%)	56 (40.3%)	>0.05
Age (years)	75.8±13.2	71.2±14.3	>0.05
Cause of pacemaker implantation			
Sick sinus syndrome (n=157)	81 (58.3%)	76 (54.7%)	>0.05
Atrioventricular block (n=121)	58 (41.7%)	63 (45.3%)	>0.05
Atrial fibrillation with slow ventricular rate (n=0)	0	0	
Pacemaker way			
DDD/DDDR model	131 (94.2%)	133 (95.7%)	>0.05
AAI/AAIR model	8 (5.8%)	6 (4.3%)	>0.05
Complications			
hypertension	63 (45.3%)	69 (49.6%)	>0.05
diabetes	49 (35.3%)	55 (39.6%)	>0.05
Coronary heart disease (CHD)	51 (36.7%)	47 (33.8%)	>0.05
Years of pacemaker implantation (years)	12.8±7.1	13.1±8.3	>0.05

APP for remote heart rhythm monitoring could replace program-controlled monitoring of pacemaker patients to the hospital and reduce the risk of patients returning to the hospital and infection with COVID-19. The application of arrhythmia monitoring APP (Anton) and patients after artificial cardiac pacemaker can help to find patients with arrhythmia, and at the same time, it can remotely monitor whether the pacemaker is working normally.

## Methods

### Recruitment of research subjects

From January 2020 to January 2021, a total of 1985 patients with permanent artificial cardiac pacemakers implanted in the Affiliated Hospital of Guangdong Medical University from January 2000 to January 2017 were screened, including 825 patients with DDD/DDDR and AAI/AAIR pacing. A total of 278 patients who were willing to participate in this observational clinical study were recruited. All patients provided written informed consent.

### Calculation of sample size

Taking the intraluminal ECG of the pacemaker program controller as the gold standard, the sensitivity and specificity of the heart rhythm monitoring APP were set as 90%, the confidence (1- $\alpha$ ) was 95%, and the tolerance error

was 0.05. The sample size was 139 cases after input into PASS software.

### Grouping of research subjects

The patients were divided into two groups according to their number of hospitalizations, patients with a single number of hospitalizations were entered into the settled rhythm monitoring group, and those with a doubled number were entered into the routine program control group. A total of 139 patients (87 males and 52 females, aged 75.8±13.2 years) were enrolled in the arrhythmic monitoring group, and 139 patients (83 males and 56 females, aged 71.2±14.3 years) were enrolled in the routine program control group. See **Table 1** for baseline data.

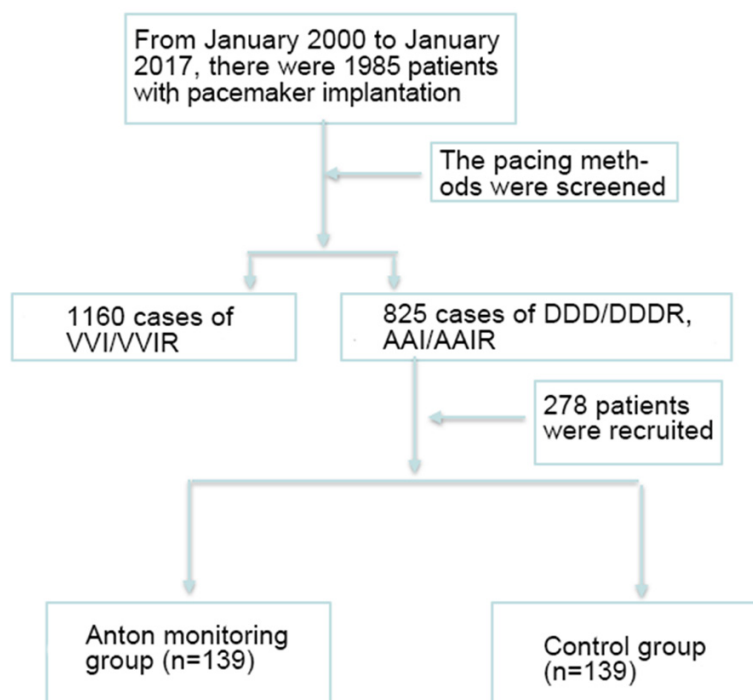
### Program control method of pacemaker

All enrolled patients went to the pacemaker program control clinic once a month to control the pacemaker parameters for 1 year, and detect the presence of high-frequency atrial events at the same time. If there were high-frequency atrial events, atrial tachycardia or atrial fibrillation this could be distinguished by intracardiac electrocardiogram.

### Anton monitoring method

The Anton rhythm bracelet was provided by Beijing Xueyang Science and Technology Co.,

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**Figure 1.** Patient enrollment process.

LTD. Patients enrolled in Anton rhythm monitoring group wore the Anton rhythm monitoring watch every day in place of going to the pacemaker programmed clinic once a month to program the pacemaker parameters, and collect heart rate, blood pressure, blood oxygen and other data every day. If their rhythm changed, the APP automatically reminded them and made a preliminary judgment of the type of arrhythmia, and the AAP automatically generated a daily health report.

Fixed rhythm monitoring means that patients with permanent pacemakers received daily health reports from a heart rate monitoring APP at home every day to see if their pacemakers are working properly. Routine rhythm monitoring means that patients with permanent pacemakers should visit the program control clinic in hospital once a year to check whether the pacemaker is working normally.

The APP includes the following indicators: EMAT refers to electro-mechanical excitation time, which is the time from the onset of ventricular excitation to mitral valve closure. EMAT% means the ratio of EMAT and RR intervals. LVST means left ventricular contraction time (time from mitral valve closure to diastole).

### *Identification and diagnosis of atrial fibrillation*

In patients with Anton rhythm monitoring, if the rhythm monitoring APP indicates atrial fibrillation, the pacemaker intracardiac ECG is obtained by using the pacemaker program controller to confirm whether it is atrial fibrillation.

### *Statistical methods*

Data were processed by SPSS software, measurement data were expressed as mean  $\pm$  standard deviation and analyzed by t test; count data were expressed as rate and analyzed by chi-square test.  $P < 0.05$  was considered as a statistical difference.

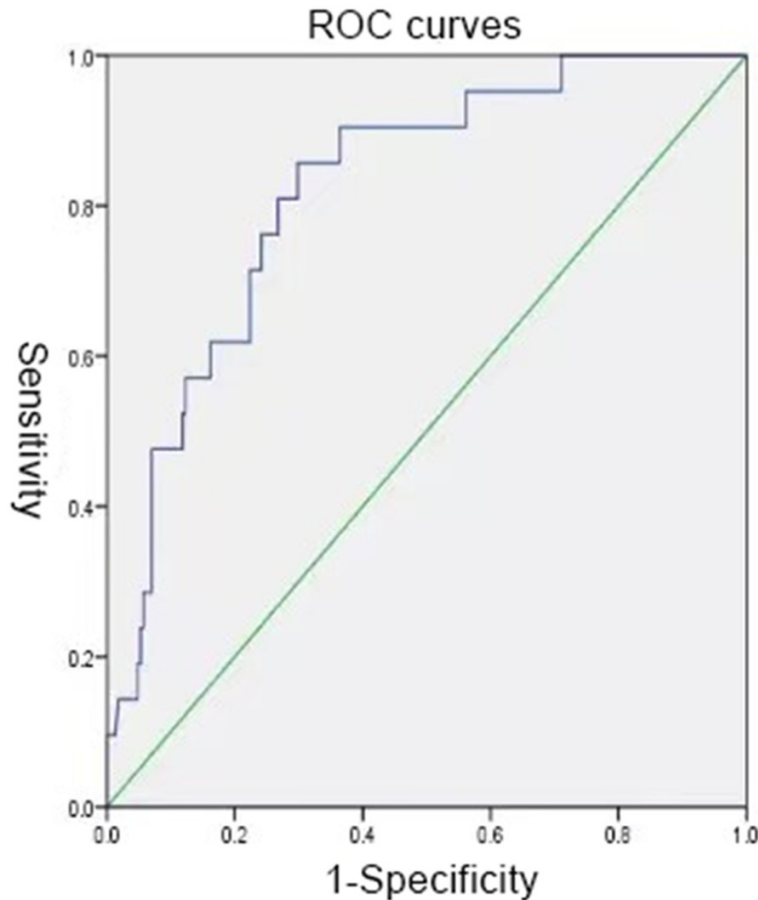
## Results

Recruitment and baseline data of the two groups (**Figure 1; Table 1**).

The incidence of atrial fibrillation was detected by pacemaker programmable controller in the two groups: The incidence of atrial fibrillation was 11.5% ( $n=16$ ) in the Anton monitoring group and 9.4% ( $n=13$ ) in the control group, and there was no significant difference between the two groups ( $\chi=40.16$ ,  $P > 0.05$ ).

Nineteen patients with atrial fibrillation were detected by rhythm monitoring APP (Anton), among which 13 patients were found to have atrial high-frequency events by pacemaker program-controlled detection, which was confirmed as atrial fibrillation by intracardiac ECG, and 6 patients were not found to have atrial high-frequency events by pacemaker program-controlled detection, and atrial fibrillation was excluded. In 3 patients, atrial fibrillation was not detected by rhythm monitoring APP (Anton), but high frequency events were detected by pacemaker program-controlled examination, and intracardiac ECG confirmed atrial fibrillation.

The sensitivity and specificity of rhythm monitoring APP (Anton) in detecting atrial fibrillation were 81.3% and 95.3%, respectively.



**Figure 2.** The ROC curve. The area under of curve of Anton APP have high diagnostic efficiency. Specificity on the horizontal axis, sensitivity on the vertical axis.

The positive predictive value of atrial fibrillation detected by rhythm monitoring APP (Anton) was 68.4%, and the negative predictive value was 97.6%.

The area under the ROC curve of APP (Anton) was 0.856, 95% confidence interval: 0.827-0.881,  $P < 0.01$  (**Figure 2**).

**Discussion**

Atrial fibrillation is the most common persistent type of arrhythmia. With the aging of the population, the incidence of atrial fibrillation is increasing annually. At present, the awareness rate and effective treatment rate of atrial fibrillation are still low in China [3], and the attention to atrial fibrillation after pacemaker surgery is even lower. Studies have shown that the longer the number of years after permanent artificial pacemaker implantation, the higher the inci-

dence of atrial fibrillation. Therefore, patients with pacemaker implantation for more than 3 years were selected in this study. It can be seen that the incidence of atrial fibrillation in the two groups of patients is higher than that in the normal population, which is similar to literature reports [4].

After implantation of artificial cardiac pacemaker, the parameters of cardiac pacemaker electrode should be monitored regularly, including pacing electrode threshold, sensing, electrode impedance, device failure, battery life termination and new atrial fibrillation, etc., so as to dynamically understand the function of cardiac pacemaker and dynamically adjust and optimize the parameters of cardiac pacemaker. The pacemaker can be programmed to detect high-frequency events in the atrium, and the presence of atrial fibrillation can be determined by intracardiac ECG. With the prolongation of pacemaker implantation time, the

incidence of long-term atrial fibrillation increases significantly, as well as the incidence of atrial fibrillation related heart failure and death [5-7]. Therefore, pacemaker function should be programmed regularly after pacemaker implantation in order to detect functional abnormalities and arrhythmias such as atrial fibrillation early.

The COVID-19 pandemic has had an unprecedented impact on healthcare systems worldwide, with particular challenges in managing patients after artificial pacemaker implantation. Artificial pacemakers are programmed to be examined face to face and present inherent risks of COVID-19, including contact and droplet transmission. COVID-19 has the highest risk of morbidity and mortality in elderly patients with existing comorbidities [8]. Patients with artificial pacemaker implantation are mainly middle-aged and elderly patients with higher

risk of infection. New guidelines or recommendations have been issued around the world to recommend home monitoring or remote monitoring of patients after implantation of artificial pacemakers [9-11], and evidence has shown that remote monitoring of patients after implantation of artificial pacemakers is safe and effective [12]. With the development of artificial intelligence, a variety of portable ECG devices have been applied to arrhythmia monitoring. The photoelectric plethysmography recording device is implanted into various portable ECG recorders such as mobile phones and watches [13, 14], and has a good accuracy rate in the diagnosis of arrhythmia [15]. Abnormal function of artificial cardiac pacemaker can be manifested by changes in heart rate and rhythm. Remote monitoring of heart rate and rhythm can indirectly understand the function of cardiac pacemaker and the existence of arrhythmia. In this study, the incidence of atrial fibrillation in patients after implantation of artificial pacemaker was monitored by rhythm monitoring APP (Anton), and compared with cardiac ECG with pacemaker program controller, the study showed that: The area under the ROC curve was 0.856, 95% confidence interval: 0.827-0.881, indicating that the rhythm monitoring APP (Anton) was effective in monitoring atrial fibrillation after pacemaker implantation. Heart rate monitor APP (Anton) in addition to monitoring the heart beating rhythm, you can also monitor the blood pressure, blood oxygen saturation and heart rate, heart rate monitor APP (Anton) multiple diseases early warning model is established, according to the changes of heart rate, blood oxygen saturation and blood pressure can alert the onset of heart failure, myocardial infarction and ischemic stroke. Elevated heart rate can be used as an indicator of worsening of various cardiovascular diseases, especially elevated heart rate accompanied by decreased blood oxygen saturation, suggesting the onset of heart failure. A sudden drop in heart rate, below the lower limit of the pacemaker's frequency, indicates a failure of the pacemaker or the lead. DDDR and AAIR are two pacing modes with frequency response function. When the body demands increase, the pacemaker frequency can be increased, and the change of heart rate can be monitored through the rhythm monitoring APP (Anton). DDD and AAI pacing mode is non-frequency response mode, and the pacing frequency is

basically fixed. When atrial fibrillation occurs, the heart beating frequency and rhythm will change, so the rhythm monitoring APP (Anton) can still monitor the changes of patients' heart rate and rhythm. For those with slow ventricular rate of atrial fibrillation or patients with high atrioventricular block with implanted VVI, or way of VVIR pacemaker, heart rate monitor APP (Anton) would not be able to identify the onset of atrial fibrillation in patients without the peacemaking; but they can still monitor the heart rate changes, especially the sudden slowing below the limit frequency, and be alert for pacemaker function or lead to malfunction.

Therefore, during the novel coronavirus epidemic, it is feasible to remotely monitor the changes in heart rate and rhythm in cardiac pacemakers using the rhythm monitoring APP (Anton).

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### Disclosure of conflict of interest

None.

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