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Discussion on the value of 48 h ambulatory electrocardiogram

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ABSTRACT

Objective: The statistical number of cases was 73 times. 66 patients entered the study, including 31 males and 35 females, aged from 17 to 86 years. Firstly, the accurate big data analysis was carried out on 66 cases of ambulatory ECG, and then the corresponding time that can be compared and analyzed before and after 24 h was determined through the time (*T*) RR interval scatter diagram. The changes of 24 h ECG scatter diagram were observed, and the total number of heart beats and the number of premature beats were counted by the scatter diagram technique, and then compared and analyzed according to the type of arrhythmia. **Results:** A frequent or occasional premature beats: 52 patients (59 times), 26 males and 26 females, aged (56.1 ± 15.4) years; the effective analysis duration was (22.40 ± 1.19) h. There was a significant correlation between the number of heart beats before and after treatment (r = 0.934, p = 0.000). Persistent arrhythmia: 4 cases of persistent atrial fibrillation (referred to as atrial fibrillation), 1 case of frequent atrial and ventricular concurrent arrhythmia, 2 males and 3 females, aged (68.4 ± 9.4) years; the effective analysis duration was (22.68 ± 0.74) h. The *t*-RR scatter plot and Lorenz RR scatter plot of these patients had self-similarity before and after 24 h. There was no significant difference in the total heart beat number before and after 24 h [(111796 ± 16439) vs. (111262 ± 16421), p = 0.624], and the total heart beat number before and after 24 h was significantly correlated (r = 0.991, p = 0.001); the qualitative diagnosis of long interval in 3 patients with atrial fibrillation was consistent 24 hours before and after diagnosis. Paroxysmal arrhythmia: 9 cases, 3 cases of paroxysmal atrial flutter, 5 cases of paroxysmal atrial fibrillation, and 1 case of paroxysmal vertical separation of sinus node function. There were 3 males and 6 females. The age was (71.2 ± 12.7) years. The effective analysis duration was (22.67 ± 0.74) H. **Conclusion:** 24 h ambulatory ECG can meet the requirements for patients with frequent or occasional premature beats and persistent arrhythmias, while 48 h ambulatory ECG may be necessary for patients with paroxysmal arrhythmias.

Keywords: cardiology; dynamic ECG; big data analysis; ECG scatter diagram; arrhythmia; 48-hour ECG

1. Introduction

The earth, where human beings live, rotates once every 24 h. When facing the sun, it is day. When departing from the sun, it is night. It is the law of human life to work at sunrise and rest at sunset. The heart rhythm that is consistent with the change of human life law also shows regular changes. Therefore, 24 h Holter detection can reflect the periodic change of human heart rate or rhythm[1]; the research shows that the occurrence of arrhythmia also shows a significant diurnal distribution[2]. Therefore, the author speculates that un-

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derstanding the change of a 24 h overall heart rhythm of patients means that we can understand all the 24 h overall heart rhythm; however, some arrhythmias may not be sporadic or frequent in a change cycle within 24 h due to some sudden factors, and it may take longer monitoring to capture the sudden events. The author divided the 48 h ambulatory electrocardiogram into two 24 h, compared the rhythm of the two 24 h monitoring, and discussed the detection and significance of the 48 h ambulatory electrocardiogram.

2. Data and methods

2.1. Observation object

The people's Hospital of Wuhan University began in January 2021. The outpatient doctors requested 48 h or 72 h dynamic ECG testing according to the needs of patients' conditions. The 48 h or 72 h dynamic ECG testing was completed by the Department of cardiac function of the hospital. The instrument was completed by the intelligent dynamic ECG analysis system produced by Hangzhou Baihui Medical Equipment Co., Ltd. The recording time could be set by computer software according to the needs at that time, when the patient has completed the corresponding recording time, import it into the computer through the corresponding software. The ECG doctor on duty will issue a report after the intelligent analysis system + manual analysis and correction, and archive the original recorded data for further analysis.

From 4 January 2021 to 3 September 2021, 59 patients (including 1 patient who performed 48 h ambulatory ECG recording twice at different times, calculated as 2 patients) performed 48 h ambulatory ECG recording, and 7 patients performed 72 h ambulatory ECG recording. In order to compare the ECG records before and after 24 h (48 h in total), the author divided the 72 h ambulatory ECG records into three 24 h periods (A, B, C). A and B, B and C were used to compare the changes of ECG records before and after 24 h; that is, 7 patients were recorded 2 times per person, so the number of cases included in the analysis and statistics was 73 times; the number of cases was 66. 66 patients, 31 males and 35 females; the youngest is 17 years old and the oldest is 86 years old.

2.2. Analysis method

In order to analyze the 48 h heart beat in detail, the author adopted modern ECG big data analysis methods: A) accuracy of 48 h or 72 h whole stroke: time (*t*) RR interval scatter plot and reverse technology combined with Lorenz RR scatter plot analysis technology can achieve accurate heart beat in general cases[3,4], and Lorenz RR scatter plot + superimposed heart beat technology is required in some special cases[5]; then refer to "histogram and histogram inversion technology" to accurately determine the heart rate of the minimum (fastest) and maximum (slowest) cardiac cycles. B) Determination and comparison of the available time course for analysis in the first 24 h and the next 24 h: for the patients who performed 48 h or 72 h ambulatory ECG detection, when they came to the hospital to remove the recording box after the second 24 h or the third 24 h, most of them failed to achieve the full 24 h recording. In order to make the heart beats in the first 24 h and the next 24 h comparable, the author chose the time course (length) of ECG actually recorded in the next 24 h as the standard available time course for analysis, then, the *t*-RR scatter chart technology is used to take the same time course in the corresponding time frame in the first 24 h as the time course available for analysis in the next 24 h for statistical measurement. The detailed method is shown in **Figure 1**.

For paired atrial premature beats (abbreviated as atrial premature beats) and atrial tachycardia (abbreviated as atrial tachycardia), if it is difficult to measure from the Lorenz RR scatter diagram, the occurrence time can be read from the "atrial premature events" for 24 h counting.

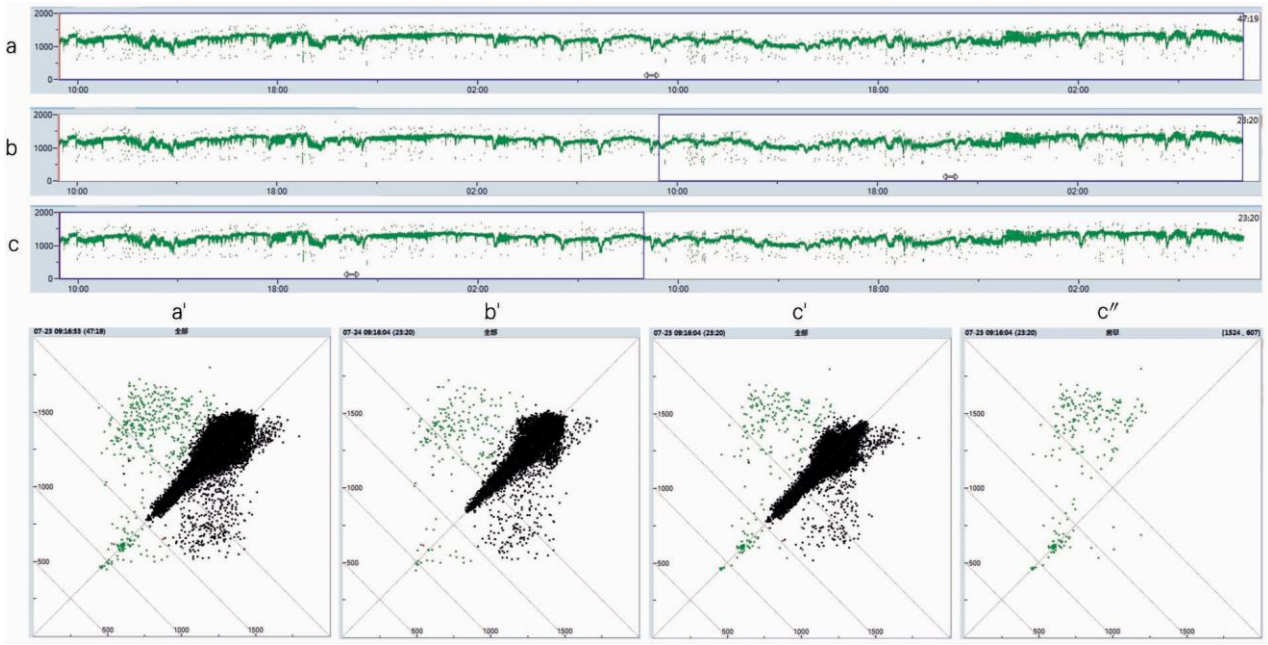

Figure 1. Available analysis time history and calculation method for 24 h before and 24 h after confirmation. The previous figure is a *t*-RR scatter diagram, a: the duration of the whole bar is set to 48 h, and the actual recording duration is 47 h 19 min (frame timing duration); article B: the time course available for analysis (23 h 20 min) recorded within the next 24 h, the starting time of which is 07-24, 09:16:04 (corresponding to the starting time of article C 07-23, 09:16:04, and the time course determined in the inner circle of the box is also 23 h 20 min). Note that the starting time of article a is 07-23, 09:16:55 (the time indicated in a'), which lags behind 16:04 by 51 s. It is speculated that 16:04 may be the power on time, and 16:55 is the time recorded by ECG; article C: the available time for analysis recorded within the first 24 h, starting at 07-23, 09:16:04 (consistent with the starting time of article b); the figure below is Lorenz RR scatter diagram. A', B', C' respectively correspond to the figure generated by the rectangular box in **Figure 1a–c** above; C″ is the "atrial premature" scattergram extracted from C′. The total number of heart beats can be calculated by framing the Lorenz RR scattergram. The total number of heart beats of a′, B′, C′ and C″ are 139,881, 69,835, 67,974 and 234 respectively (atrial premature number includes all ectopic atrial beats, such as the number of atrial beats of paired atrial premature and atrial tachycardia). A′, B′, C′ in the figure have obvious self-similarity, and the accompanying arrhythmia is atrial parallel arrhythmia.

2.3. Statistical grouping

After accurate analysis and statistical measurement of all cases, the author found that for the convenience of scientific analysis, the following categories are more appropriate: a) patients with frequent or occasional premature beats are the first category; b) persistent atrial fibrillation (AF) is the second type; c) paroxysmal arrhythmias, such as paroxysmal atrial fibrillation and atrial flutter (referred to as atrial flutter) are classified into the third category. The diagnosis of types of atrial premature beats and ventricular premature beats (referred to as ventricular premature beats) is based on the graphic characteristics of big data in clinical ECG scatter[6,7]. Longitudinal separation of sinus node function and sinus escape reference[8,9].

2.4. Statistical treatment

SPSS statistical software was used for statistical analysis. The data of measurement data are expressed in $X \pm s$, and paired *t*-test is adopted; if the distribution is skewed, it is expressed by median + quartile [*m*(P25, p75)], and rank sum test is used; the correlation was tested by paired samples. The difference was significant ($p < 0.05$).

3. Results

3.1. Type I: Frequent or accidental premature beats

The recording time of 45 cases was 48 h, and that of 7 cases was 72 h (combined before and after 48 h, 2 cases were calculated), a total of 52 patients (59 cases). Among them, there were 26 males and 26 females, the

age was (56.1 ± 15.4) years old, and the duration was (2769.67 ± 496.60) min (mean 46.15 h); the effective analysis duration was (1345.75 ± 71.27) min (mean 22.40 h). All patients had premature beats, of which the least was 1 atrial premature beat and the most was 14,410 ventricular premature beats. There were 37 cases of atrial concurrent rhythm and 2 cases of borderline concurrent rhythm; there were 1 case of reentrant atrial premature beats and 6 cases of atrial premature beats of undetermined nature (the number of atrial premature beats was too small to form a characteristic scatter diagram); there were 14 cases of ventricular concurrent rhythm, 5 cases of reentrant ventricular tachycardia, 13 cases of undetermined ventricular tachycardia (the number of ventricular tachycardia was small and did not constitute a characteristic scatter plot), and 32 cases of both atrial and ventricular tachycardia.

The *t*-RR scatter plot and Lorenz RR scatter plot of this kind of patients before and after 24 h have self-similarity (the shape of the formed graph is similar), as shown in **Figure 1**. There was no significant difference in the total number of heart beats, atrial premature beats, paired atrial premature beats, atrial tachycardia and ventricular premature beats between the first 24 h and the second 24 h in 59 patients ($P > 0.05$); see **Table 1**. There was a significant correlation between the total heart beat number before and after 24 h ($r = 0.934$, $p = 0.000$).

Table 1. Comparison of total heart beats, atrial premature beats, atrial tachycardia array and ventricular premature beats recorded in 24 h before and after 48 h Holter recording ($n = 59$).

Category	Total heart beats	Room breakfast/piece	Paired room breakfast/time	Atrial tachycardia/time	Room breakfast/piece
First 24 h	92,256 ± 12,151	26(5,101)	0(0,2)	0(0,1)	2(0,20)
After 24 h	92,638 ± 11,978	27(5,97)	0(0,1)	0(0,1)	1(0,10)
P	0.507	0.509	0.294	0.924	0.927

3.2. Type II: Persistent arrhythmia

Among 4 patients with persistent atrial fibrillation, 1 patient with frequent atrial and ventricular fibrillation recorded a 48 h *t*-RR scatter plot like that of persistent atrial fibrillation (heart rate is absolutely uneven), as shown in **Figure 2**, so 5 patients were included in the observation. There were 2 males and 3 females with an average age of (68.4 ± 9.4) years; the recording time course was (2800.40 ± 44.70) min (mean 46.67 h), and the analysis time course was (1360.6 ± 44.66) min (mean 22.68 h).

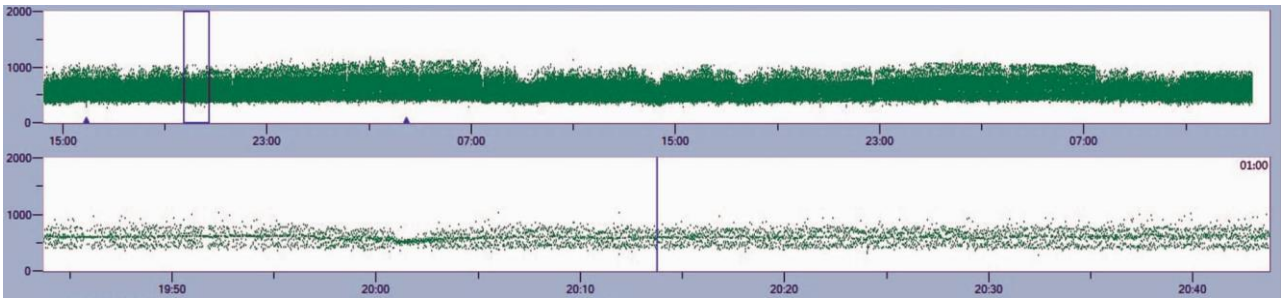

Figure 2. *T*-RR scatter plot of sinus rhythm with frequent atrial and ventricular concurrent rhythms.

The patient, a 79-year-old male, had sinus rhythm, atrial union and ventricular union repeatedly and alternately in 48 h, resulting in absolute irregularity of ventricular rate. Therefore, the scatter pattern formed in the above graph is similar to that of atrial fibrillation; the following **Figure 3** is an enlarged *t*-RR scatter diagram (the time length is relaxed, but the length of the vertical axis remains unchanged) of the 1H scatter diagram framed in the box in the previous **Figure 2**. The "thin line" in the middle is a sinus rhythm point, forming a thin and straight "curve", and its variability is reduced.

The *t*-RR scatter plot and Lorenz RR scatter plot of this kind of patients also have self-similarity. For example, the curve shape of *t*-RR scatter plot at 24 h before and after **Figure 2** remains unchanged. There was no significant difference in the total heart beats recorded in the five cases before and after 24 h [(111,796 ± 16,439) vs. (111,262 ± 16,421), $p = 0.624$], and there was also a significant correlation between the total heart beats recorded in the five cases before and after 24 h ($r = 0.991$, $p = 0.001$). There were 3 patients with persistent atrial fibrillation who had long intervals. The frequency of long intervals was the same in 2 patients before and after 24 h (>2 s was 7, 7 and 1, 1 respectively), while the number of long intervals in the first 24 h was more than that in the next 24 h (>2 s, 124 times; >2.5 s, 6 times vs. >2 s, 69 times; >2.5 s, 1 time).

3.3. Category III: Paroxysmal arrhythmia

Nine patients with paroxysmal arrhythmia, including 3 males and 6 females, aged (71.2 ± 12.7) years, were recorded for (2799.67 ± 45.09) min (mean 46.66 h) and analyzed for (1360.00 ± 44.32) min (mean 22.67 h). Among them, there were 3 cases of paroxysmal atrial flutter, 5 cases of paroxysmal atrial fibrillation, and 1 case of paroxysmal vertical separation of sinus node function. Basal heart rate: sinus rhythm combined with reentrant atrial tachycardia in 3 cases and atrial complication in 4 cases; one case had both reentrant atrial tachycardia and concurrent rhythmic atrial tachycardia.

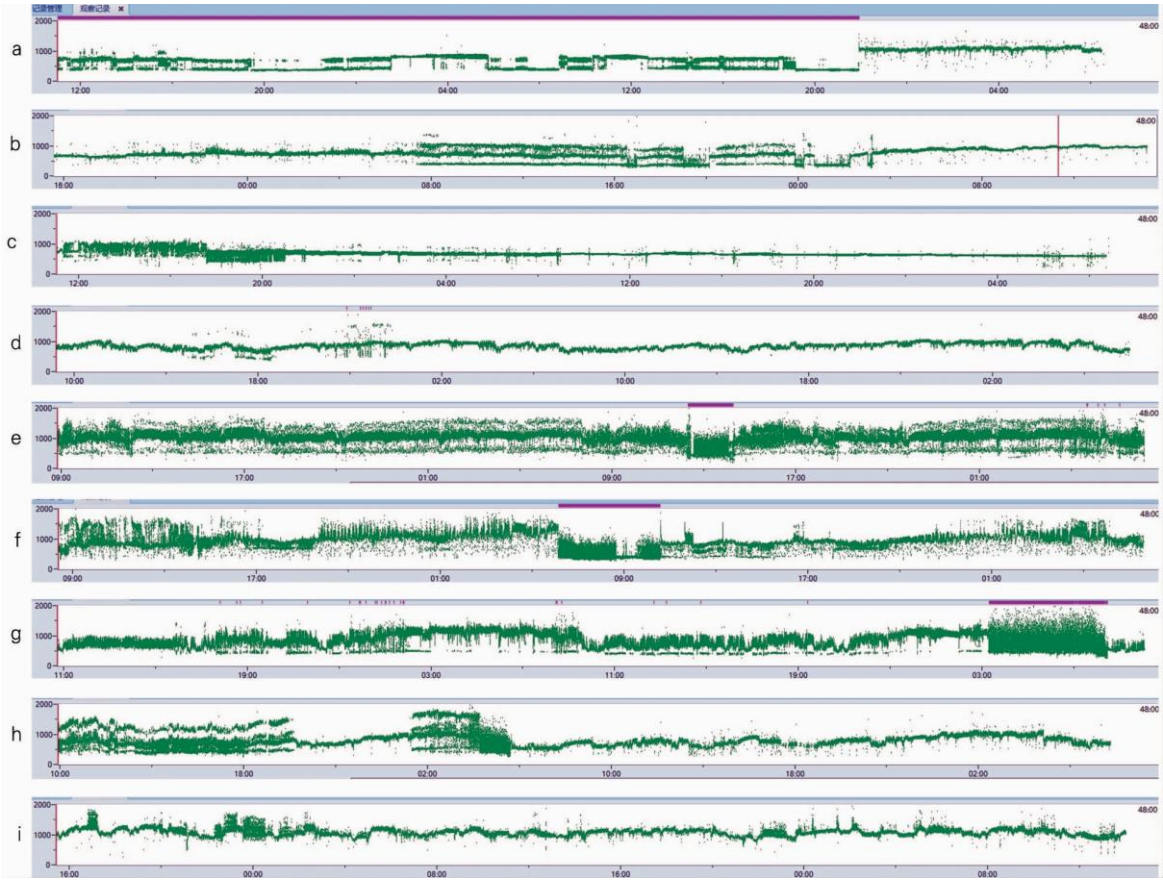

Figure 3. *T*-RR scatter diagram automatically drawn by computer in 48 h ECG recording of patients with paroxysmal arrhythmia. The *t*-RR scatter gram (comparison of anterior and posterior segments) of 9 patients before and after 24 h were significantly different, and the self-similarity disappeared. A—a female patient, 84 years old, had atrial flutter in the first 24 h, mainly passing down the ventricle at 2:1 and 4:1; in the next 24 h, the first 11 h were atrial flutter, and the last 10 h and 36 min were sinus rhythm and atrial concurrent rhythm. B and A were the same patient, which were recorded after 9 days of atrial flutter treatment. In the first 24 h, the first 15 h and 50 min were sinus rhythm with occasional atrial fibrillation; the later stage was associated with frequent reentrant atrial tachycardia; in the next 24 h, frequent reentrant atrial premature beats continued to occur, and on this basis, short bursts of atrial flutter occurred 4 times. The total duration was 10 h 42 min, and then turned to sinus rhythm (during which a short atrial flutter occurred once, lasting for 9 min). C patient was a 68 year old male with sinus rhythm + borderline rhythm + borderline escape at the beginning of the first 24 h, lasting for 6 h 32 min, followed by atrial tachycardia with different degrees of atrioventricular block; after that, the rate of

atrial tachycardia was 2:1 downward; after 24 h, the continuous constant atrial tachycardia was 2:1 downward. D—the patient was a 69-year-old male, who had frequent atrial tachycardia within the first 24 Hours, and the atrial tachycardia did not pass down; short paroxysmal atrial fibrillation occurred 6 times, lasting from 23 s to 1 min 12 s; the whole course of 24 h was sinus rhythm. E patient was an 82-year-old male with sinus rhythm and frequent atrial fibrillation in the first 24 h; on the basis of atrial union, paroxysmal atrial flutter/fibrillation occurred 24 h later, lasting for 1 h and 43 min. F patient was a 74 year old female with sinus rhythm and atrial fibrillation at 48 h; atrial flutter/fibrillation occurred at the junction of the first 24 h and the second 24 h, lasting for 4 h 26 min. G patient was a 42 year old male, whose basic rhythm was sinus rhythm with reentrant atrial tachycardia at 48 h. In the first 24 h, there were 17 short bursts of atrial fibrillation, all lasting for about 1 min; atrial fibrillation with a long duration occurred 24 h later, lasting for a total of 5 h 9 min. H—female, 61 years old, the basic rhythm of 48 h was sinus rhythm with atrial Union, and atrial premature beats did not pass down; in the first 24 h, there were two periods of frequent atrial fibrillation, the duration of which was 10 h 11 min and 3 h respectively. In the later period, atrial fibrillation occurred on this basis (the duration of which was 1 h 22 min); after 24 h, sinus rhythm combined with occasional atrial fibrillation. I—a 77 year old female patient whose basic rhythm was sinus rhythm with longitudinal separation of sinus node function and sinus escape; there were 6 attacks in the first 24 h, and the duration was long. There were also 6 attacks in the second 24 h, but the duration was short.

The self-similarity of *t*-RR scatter plot and Lorenz RR scatter plot of this kind of patients disappeared 24 h before and after treatment, as shown in **Figures 3** and **4**. There was no significant difference in the total number of heart beats in 9 cases before and after 48 h [(100,709 ± 23,017) vs. (99,429 ± 17,909), $p = 0.823$]. There was a correlation between the total number of heart beats before and after 24 h ($r = 0.695$, $p = 0.038$).

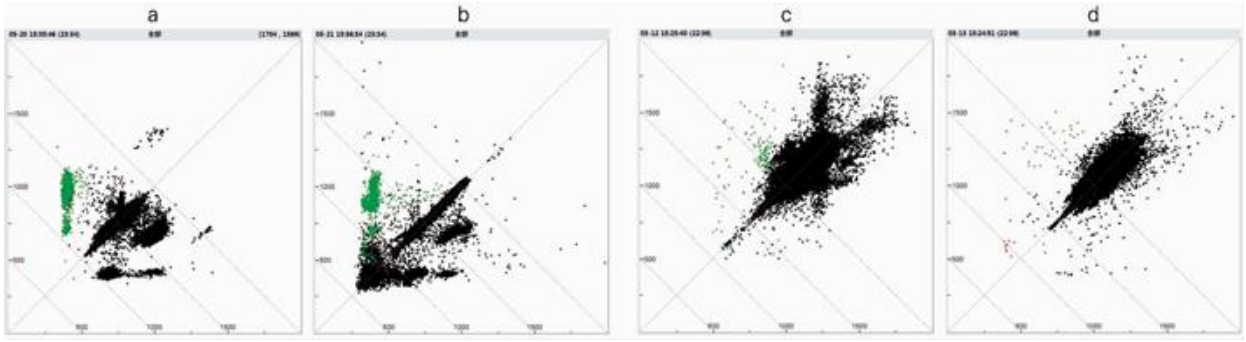

Figure 4. Front and rear 24 h Lorenz RR scatter plots of 2 patients (B and I), selected from the *t*-RR scatter plot in **Figure 3**. A, B, C and D are the 24 h Lorenz RR scatter plots of the same patient, respectively. It can be seen that their self-similarity disappears, indicating that one of them has arrhythmia or has different degrees.

4. Discussion

4.1. Findings of this study

A) Through the 24 h performance of common arrhythmia atrial premature and ventricular premature of 59 patients in this study, it is found that the morphological characteristics of big data scatter diagram have not changed and have significant "self similarity", which is the "chaotic" performance of cardiac rhythm and reflects the "periodic phenomenon" of beating[10], and it is also found in the 48 h statistical data, there was no significant difference in total heart beat number, atrial premature beats, paired atrial premature beats, atrial tachycardia and the total number of ventricular premature beats before and after 24 h, and there was a significant correlation between total heart beat number before and after 24 h ($r = 0.934$, $p = 0.000$), indicating that for the detection of common arrhythmias (atrial premature beats and ventricular premature beats), 24 h long-range ECG examination was enough to find their apparent characteristics, and 48 h long-range ECG examination was not necessary. B) In this study, the ECG big data of patients with persistent arrhythmia (4 cases of atrial fibrillation, 1 case of frequent atrial and ventricular Union) were analyzed for 48 hours. It was also found that the morphology of the scatter plot before and after 24 h was also self-similar, and there was no difference in the total number of heart beats before and after, and it was highly similar ($r = 0.991$, $p = 0.001$). It also showed that the long-range ECG examination for 24 h in patients with this kind of arrhythmia was enough, and the examination for 48 h was not necessary. C) Nine patients with paroxysmal arrhythmia were examined by dynamic electrocardiogram for 48 h. It was found that the shape of the scatter diagram had changed and its

self-similarity had disappeared, indicating that the nature of their heart rhythm had changed; according to the statistical data, these 9 cases all had paroxysmal arrhythmias of different degrees, and each had its own nature and characteristics. However, the 24-hour overall rhythm characteristics could not show the nature and characteristics of their occurrence. Therefore, it is necessary to monitor the ECG of these patients for 48 h.

4.2. Characteristics and long-term record of arrhythmia

Atrial premature and ventricular premature are the most common arrhythmias. In the 24-hour human activity cycle, the time length can provide the opportunity or opportunity for the occurrence of atrial premature and ventricular premature. Therefore, 24-hour ECG examination is enough to make qualitative or quantitative diagnosis for patients; for patients with persistent arrhythmia, there is no qualitative change in the nature of 24 h and 48 h duration and the number of heart beats, so only 24 h ECG monitoring is required to detect problems, and 48 h examination is not necessary; the occurrence and termination of paroxysmal arrhythmia may be greatly affected by sudden factors, and the length of 24 h is not enough to reflect the characteristics of its occurrence, development and cessation, so it is necessary to monitor ECG for 48 h or longer. So, before applying for the long-term ambulatory ECG examination, how do clinicians determine whether a patient needs 24 h or 48 h examination? This requires clinicians to ask the patient's symptoms and medical history in detail, observe the conventional 12 lead ECG, preliminarily determine the nature of arrhythmia, and then select the inspection duration of long-range ECG. Only in this way can we make rational use of resources and provide the best inspection means for patients.

Conflict of interest

The authors declare no conflict of interest.

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