Journal of Clinical and Nursing Research

Research Article

The Value of the Wearable Single-lead Remote Monitoring Device with the Scatterplot in Chronic Disease Management

Xinyan Yu[1], Qinghong Zhang[2], Dong Wang[2], Yan Feng[2], Fangjie Li[1]

[1]The First People's Hospital of Yinchuan, Yinchuan 750001, Ningxia Province, China

[2]Wang Jing Hospital of CACMS, Beijing 100102, China

Funding: The Special Project of Science and technology benefit the people of Ningxia Hui Autonomous Region(2018CMG03015)

Abstract: ***Objective:*** To study the value of the wearable single-lead remote monitoring device with the scatterplot in chronic disease management. ***Methods:*** dmitted into 435 residents accord with the inclusion criteria of 20 primary medical institutions of Yinchuan city, and grouped voluntarily by the implementation schemes were grouped voluntarily according to the implementation schemes. According to one of the three implementation schemes selected, the general practitioner guided the subjects to take on the wearable single-lead remote monitoring device, collecting and uploading the EEG data, then diagnosed and analyzed by the synchronously generated ECG scatterplot, finally, summarized the incidence and the categories, analyzed the differences among these three groups. ***Results:*** Among 435 subjects, there were 61 normal patients and 374 arrhythmias with the detection rate of 85.98%; and among the 1672 data collected, there were 606 normal data and 1066 arrhythmia with the detection rate of 63.76%; 880 data in total 333 cases with atrial premature beat; 442 data in total 215 cases with occasional ventricular premature beat; 37 data of 22 cases with frequent atrial beat; 65 data of 28 cases with frequent ventricular premature beat; 13 data of 6 cases with atrial fibrillation; 25 data of 15 cases with excitation conduction disorder; 2 data of 2 cases with atrial flutter; 31 data of 19 cases with ventricular tachycardia; 30 data of 16 cases with conduction block; and 14 data of 8 cases with Para systolic rhythm. comparing the detection rate of arrhythmia in three groups, the difference was not statistically significant (P>0.05). ***Conclusion:*** The wearable single-lead remote monitoring device with the scatterplot has high application value in cardiovascular chronic disease management. Its effectively screening, validly diagnosing and detailed classifying are helpful to the early intervention, and the protection of the patients' lives.

Keywords: Chronic disease management; Arrhythmia; Wearable single-lead device; Scatterplot

Publication date: May, 2020

Publication online: 31 March, 2020

***Corresponding author:** Fangjie Li, lifangjie5166@163.com

There is a continuous increasing incidence of chronic cardiovascular disease along with the population aging, mostly accompanied with arhythmical. Therefore, to the chronic disease management of chronic cardiovascular disease is attaching more attention. In clinical practice, arrhythmia is often examined with the routine 12-lead resting electrocardiogram or 24-hour dynamic electrocardiogram. However, due to the transient and sudden characteristics of arrhythmia, the symptoms of palpitation and arrhythmia in some patients may fail to be caught for the short collection time of the resting electrocardiogram in the hospital. In addition, even for those who wear the 24-hour dynamic electrocardiogram, factors like the appointment, playback as well as inadequate professional warning may also cause the lapse of the optimal time for wearing, diagnosis and

treatment, and even sudden death. In recent years, with the development of medical technology, the wearable remote monitoring device has been gradually used and can effectively over come the bottleneck of traditional examination methods [1-2]. As a common method for the clinical diagnosis of arrhythmia, the electrocardiographic waveform diagram is complex and hard to master for non-professionals, while the ECG scatterplot can turn the complex electrocardiogram only for professionals into the geometry for non-professionals and even ordinary people[3-4]. The wearable remote monitoring device chosen in this study supports patients to record and synchronize the ECG data at home to generate the ECG scatterplot for the grass-roots general practitioner to preliminarily diagnose and screen. Meanwhile, the patients' families after training could recognize the common pattern, which effectively reduce the misdiagnose and lower the incidence of sudden death. Therefore, this study is to explore the value of the convenient wearable device and the scatterplot with the advantages in the expression of arrhythmia in chronic disease management with the remote monitoring technology, as follows.

1 Data and Methods

1.1 General Information

435 community residents eligible for inclusion criteria of 20 primary medical institutions of Yinchuan City were involved, including 177 males and 258 femaleage 19-84 and 51.98 on average; 61 normal residents of 18 males and 43 females aged 19-76 and averagely aged 43.82, and 374 non-normal residents of 159 males and 215 females aged 20-84 and averagely aged 53.31; 227 residents with high-school level or below of 95 males and 132 females aged 29-84 and averagely 59.93 and 208 residents with above high-school level of 82 males and 126 females aged 19-77 and averagely 43.30. This study conforms to the norms of medical ethics and all participants in the screening have signed the informed consent.

1.2 Inclusion Criteria

1.2.1 Inclusion Conditions

(1)A history of unexplained amaurosis or syncope; (2)A family history of hereditary arrhythmia; (3)Have family members with sudden unexpected death; (4)Have a frequent arrhythmia with unclear diagnosis; (5)Had arrhythmia surgery (including radiofrequency ablation and pacemaker implantation) that needs a postoperative follow-up and observation; (6)Signed up the informed consent.

1.2.2 Exclusion conditions

Compromise on smart phone; Those with mental illness; Unavailable to a domestic or surrounding 4G network; Dropped out during the study.

1.3 Methods

1.3.1 Usage Methods

The ECG signals of patients were recorded with the wearable single-lead dynamic ECG recorder produced by Synwing Tech. according to the implementation scheme. Then, the automatic computer detection technology was combined to finish the qualitative analysis of the body's ECG condition and draw the corresponding ECG scatterplot. Meanwhile, data extracted were uploaded *via* the Internet. The real-time information of those subjects shall be processed and preliminarily diagnosed by trained general practitioners, and can be uploaded to the expert diagnosis center for exact diagnosis through the cloud platform if any difficulty occurs, and then the diagnosis results would be returned to the general practitioners.

1.3.1.1 Electrode Placement Location

Attached the white line electrode (RA) to the intersection of the right midclavicular line and the second rib, the electrode of the black line (RL) should be attached to the lower right abdomen as a reference point, and the electrode of the red line (LL) should be attached to the lower left abdomen. Data is transmitted via Bluetooth 5.0 (Compatible with 4.x).

1.3.1.2 The instruction & Procedure (Holter Mode) of the Doctor APP

The general practitioners help patients wear the device, control, and measure with the mobile APP. when the patients back to the fundamental institution after a 24 to 72hs leave. The practitioner connects the device with the mobile APP, extracts and uploads the data stored in the device.

1.3.1.3 The Usage Method & Procedure (Holter Mode) of the Patient APP

Patients install the APP on their mobile phones and wear the device themselves. When a patient takes the mobile phone, the APP can measure and upload the real-time data to the cloud. If separated from the patient, the

wearable device will automatically store, and upload the test data after connecting the smartphone when the patient approaches it.

1.3.2 Implement Scheme

Group A (Scheme One): The total record time for each case is two weeks. For the first time, each case should be recorded continuously for 24 hours, followed by two 24-hour tests in the community within 2 weeks. The doctor APP procedure should be followed.

Group B (Scheme Two): The total record time for each case is one week. Each case should be recorded once for 24 hours, and three times at least for 1 hour. There are no requirements for the upper limit. The patient APP procedure should be followed.

Group C (Scheme Three): The total record time for each case is one week. For the first time, each case should be recorded continuously for 72 hours, followed by a 1-hour test in the community within the next 4 days. There are no requirements for the upper limit. The patient APP procedure should be followed.

1.4 Diagnostic Criteria

Clinical Practical Electrocardiography and *ECG Scatterplot* can be referred; A patient can be regarded as abnormal if one data is abnormal.

1.5 Observation Indicator

Summarizing the diagnosis data obtained from the ECG scatterplot, calculating the incidence and classification, and analyzing the difference among three groups.

1.6 Statistical Methods

Using SPSS 20.0 software for data processing, the measurement data can be expressed as $\bar{x} \pm s$, tested by *t,* and the count data can be expressed by percentage, tested by χ^2. If $P<0.05$, the difference is statically significant.

2 Results

Among 435 subjects, there were 61 normal patients and 374 arrhythmias with a detection rate of 85.98%; and among the 1672 data collected, there were 606 normal data and 1066 arrhythmia with a detection rate of 63.76%; 880 data in total of 333 cases with atrial premature beat; 442 data in total of 215 cases with occasional ventricular premature beat; 37 data of 22 cases with frequent atrial beat; 65 data of 28 cases with frequent ventricular premature beat; 13 data of 6 cases with atrial fibrillation; 25 data of 15 cases with excitation conduction disorder; 2 data of 2 cases with atrial flutter; 31 data of 19 cases with ventricular tachycardia; 30 data of 16 cases with conduction block; and 14 data of 8 cases with perisystolic rhythm. Through comparing the detection rate of arrhythmia in three groups, the difference was not statistically significant (χ^2=1.305, P=0.521), shown in Table 1.

Table 1. Comparison of the arrhythmia detection rate of patients in the three groups n（%）

Group	Normal	Abnormal	Total
Group A	44(13.71)	277(86.29)	321(100.00)
Group B	6(15.00)	34(85.00)	40(100.00)
Group C	11(14.86)	63(85.14)	74(100.00)

3 Discussion

In China, the most common chronic diseases such as diabetes and hypertension cause adverse cardiovascular easily, especially arrhythmia, of which incidence is higher in those with chronic diseases than in those without chronic diseases[5-7]. Commonly induced by myocardiopathy, heart failure and acute myocardial infarction and so on, arrhythmia has a complex etiology.

Once the malignant arrythmia is induced, it could induce hemodynamic disorders in a short period, resulting in syncope or even sudden death of patients. Hence monitoring and management of arrhythmia for patients with chronic diseases have become the key to ensure the safety of their lives. Nowadays, as the major institutions of the chronic disease management, the primary hospitals are responsible for the continuous assessment and phase evaluation. However, traditional examination methods with miscellaneous procedures fail to diagnose arrhythmia timely and effectively. While the developing Internet, smartphones, tablets, and other mobile devices have been widely used and APP has also become an important access for mobile Internet users. The combination of wearable devices, mobile devices and APP can effectively solve the problem of a long-term health follow-up, and reduce the round trip

for patients between the hospital and home, which not only saves patients' energy, but optimizes the utilization of limited medical resources[8].

According to the results, symptoms of atrial premature beats, ventricular premature beats, supraventricular premature beats, atrial fibrillation, atrial flutter and excitation conduction disorder can be effectively detected with the wearable single-lead remote monitoring device and the ECG scatterplot. No significant difference was found in the discovery of arrhythmia in the three schemes, indicating a high application value of the wearable single-lead remote monitoring device and the ECG scatterplot for the management of cardiovascular chronic diseases. The wearable device used in this study is light, convenient, and easy, patients can measure and record the ECG data by fixing three electrodes. Meanwhile, patients can install the APP and upload the data to the cloud after connecting the device, when the smartphone is separated from the patient, the test data will be stored in the device and then automatically uploaded to the cloud when the patient approaches the smartphone. The general practitioners can extract patients' data for analysis at any time; Without a smartphone, patients can connect the device with the mobile APP of the general practitioner, extract and upload the heart rate information to the cloud for access at any time to compare and analyze. In addition, continuous record time of the wearable single-lead remote monitoring device is 72 hours, which is of great significance for the difficult-to-capture arrhythmia. Another advantage of this device is the auxiliary analysis of the ECG scatterplot to enhance the efficiency, which can reflect the whole-day heart rate changes of a patient with the real-time dynamic ECG data. converting the mass dynamic ECG data into a graphical way, the ECG scatterplot can show visual and simple results for the grass-roots general practitioners and patients after training, which can effectively reduce the technical threshold of arrhythmia screening and diagnosis, it could also enhance the clinical efficiency of primary hospitals so that arrhythmia can be quickly screened and pre-determined, thenthe further graded diagnosis and early intervention can be conducted[9-11]. In addition, there is high consistency between the ECG scatterplot and waveform diagnosis with a coincidence rate of 97.8%, indicating the reliance of the ECG scatterplot in the chronic disease management of cardiovascular diseases for the primary general practitioners.

Among the three schemes in this study, most subjects chose Scheme One, which might be for the doctor APP model in Scheme One, that is, the subject can move easily, do not need to operate himself/herself and trust the general practitioner. However, for those patients with mobility difficulties and distant from the grass-root hospital, especially those with infrequent and irregular incidence, Scheme One or Scheme Three with the patient APP is recommended for the screening and monitoring of arrhythmia. It will be more conducive for the capture of arrhythmia and can achieve a real-time monitoring function. Therefore, the promotion should be strengthened later so the subjects can wear the device at home or work at any time.

During using process, continuously improving according to the specific application and feedback has been made. (1)Due to the limits of Bluetooth , the time of uploading 72-hour data to the cloud with doctors 'smartphone APP is too long, and calls cannot be made during the uploading period, otherwise, the uploading time will be insufficient and the uploaded data will be incomplete; In the later usage after improvement, the uploading time is significantly shortened and calls during uploading do not affect the process. Meanwhile, instructions of the patient APP in this scheme have been added to ensure a real-time upload of data. In addition, the efficiency can be further enhanced if tablets can be equipped. (2)Some seriously interfered signals even influence the interpretation; The anti-interference ability has been enhanced by improving and replacing the lead line later. (3)Manual re-screening is needed for poor recognition after interference; Later, the optimized algorithm can be greatly enhanced the recognition of the interference. In addition, multiple updates of software and firmware according to the project needs and feedback from researchers and subjects can ensure a high-quality and efficient analysis of the precise project data, add the options of schemes to better achieve the screening and monitoring of patients with chronic disease at home have enhanced the value of the wearable remote monitoring device in the sustainable monitoring management of chronic diseases

In conclusion, with a high value in cardiovascular chronic disease management, such as effectively diagnosing and classifying arrhythmia, conducting a real-time monitoring as well as early warning, the wearable single-lead remote monitoring device should be widely promoted among the primary hospitals to motivate the subjective initiative of the grass-roots

doctors and to enhance the technical level of the grass-roots staff, then further supports the chronic disease management and graded diagnosis and treatment[13].

References

[1] Yao Y, Jiang H, Chen ML, et al. Risk stratification and early prevention of malignant ventricular arrhythmia: rationale and design[J]. Chinese Journal of Cardiac Arrhythmias, 2018, 22(3): 187-191.

[2] Zheng GZ. Comparison of sensitivity and specificity between conventional 12 lead electrocardiogram and 24 h dynamic electrocardiogram in patients with pacemaker implantation[J]. Journal of Clinical and Experimental Medicine, 2016, 15(9): 905-907.

[3] Li FJ. ECG scatterplot: a new horizon for big data analysis[J]. Journal of Practical Electrocardiology, 2018, 27(1): 7-10.

[4] Li FJ. Focus on the clinical application of ECG scatterplot[J]. Journal of Clinical Electrocardiology, 2012, 21(1): 3-6.

[5] Movahed MR, Hashemzadeh M, Jamal M. Increased prevalence of ventricular fibrillation in patients with type 2 diabetes mellitus[J]. Heart Vessels, 2007, 22(4): 251-258.

[6] Chen WT, Du K, Liu LH. Clinical characteristics analysis of arrhythmia in patients with type 2 diabetes[J]. Journal of lingnan journal of cardiovascular disease, 2012(4): 360-363.

[7] Jin YH, Fang NY, Lu HH, et al. Relationship between the changes of cardiac structure and arrhythmia in senile hypertensive patients[J]. Academic Journal of Shanghai Second Medical University, 2004, 24 (s1): 49-52.

[8] Wang YL, Zhang W, Wang WC. Practical exploration of “Internet + healthcare” in Yinchuan city[J]. Chinese Journal of Hospital Administration, 2019, 35(8): 623-626.

[9] Shen DP, Mu XF, Li JW, et al. Design and Application of the Follow-up Management Platform for Chronic Diseases Based on "Internet + Medical Treatment" [J]. China Digital Medicine, 2019, 14(5): 49-51.

[10] Fan S. Design and implementation of telemedicine system based on wearable technology [J]. Electronic Design Engineering, 2017, 25(10): 186-189, 193.

[11] Guo JH. Technology of remote electrocardiogram monitor-thinking about internet medicine[J]. Journal of Clinical Cardiology, 2016, 32(11): 1071-1075.

[12] Chi F, Zhang SY, Zhao W, et al. Burst words detection-based technological opportunities of wearable devices in healthcare[J]. Chinese Journal of Medical Library and Information Science, 2018, 27(3): 38-43.

[13] Yu XY, Shi X, Zhao RQ. Experience and effect evaluation of the construction of ECG consortium in Yinchuan first people's hospital[J]. Gems of Health (Late), 2019, 12(36): 293.