

Review

Treatment models of cardiac rehabilitation in patients with coronary heart disease and related factors affecting patient compliance

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Coronary heart disease is a serious threat to human health. In China, medical care for the population has been focused on therapy with little follow-up of treated patients. The efficacy of therapy; however, is highly dependent on post-therapy recovery. Cardiac rehabilitation can significantly enhance patient physical strength and help delay and prevent the development of coronary atherosclerosis. Although the clinical significance of cardiac rehabilitation has been established, the compliance of patients is generally low. In efforts to improve patient compliance, domestic and foreign researchers have extensively studied and applied treatment models of cardiac rehabilitation according to the specific conditions and cultural background of each country. This study aimed to review the treatment models of cardiac rehabilitation in patients with coronary heart disease and related factors affecting patient compliance to provide a better perspective of how patients with coronary heart disease can benefit from cardiac rehabilitation.

Keywords

Coronary heart disease; cardiac rehabilitation; treatment; compliance

1. Introduction

With the improvement of living standards of populations, coronary heart disease (CHD) has increasingly become a global health problem and a primary cause of morbidity and premature death worldwide (Albarrati et al., 2018). A number of risk factors contribute to the increased risk of CHD including hypertension, hyperlipidemia, aging, and diabetes (Saygin et al., 2018). According to the 2016 World Health Organization global disease assessment report, cardiovascular diseases (CVDs) have been the leading cause of death in the last 10 years (Zheng et al., 2018). The number of patients with CVD in China has exceeded 290 million; the number

of people with CHD is 11 million with an annual increase rate of 20%. Moreover, it is estimated that by 2020, the number of deaths from CHD will reach 25 million worldwide (Beatty et al., 2018). CHD has a serious impact on the quality of life and mental state of the patients (Dorje et al., 2018). The incidence of depressive symptoms in patients with CHD was reported to be 77.23% (Im et al., 2018). An abnormal psychological state can significantly increase the risk of cardiovascular events, disrupt the hypothalamic-pituitary axis, affect endothelial cell function, and ultimately lead to increased myocardial oxygen consumption, thus aggravating or triggering the development of cardiovascular adverse events such as angina (Dalal et al., 2019).

Despite the well-described benefits of cardiac rehabilitation (CR) on long-term health outcomes, it is underutilized by a significant proportion of patients with CVD. In addition to the late introduction of CR in China, statistics show that > 90% of cardiovascular departments have not performed stage I CR (Xiaocui, 2012). Compared with European and American countries, China is still at the preliminary stage of developing CR, and there remain enormous challenges in the understanding and clinical practice of CR in the country (Xiaodan et al., 2018). Although the clinical importance of CR has been recognized by most countries, CR is developing rather slowly in China owing to inadequate attention, the unique social medical system, and health care policy, family economic restrictions and transportation difficulties etc (Zhang et al., 2017). In view of this background, domestic and foreign researchers have extensively studied and applied treatment models of CR according to the specific conditions and cultural background of each country to improve patient compliance. This study briefly reviews the treatment models of CR and related factors that may affect patient compliance, so that patients with CHD can select the best rehabilitation model based on individual physical conditions and needs. Simultaneously, medical administrators can continu-

Table 1. Treatment models and characteristics of previous studies

Treatment models	Researchers	Evaluation/monitoring methods	Advantages and disadvantages
Hospital-based CR	Kim (Kim et al., 2011) Martinez (Martinez et al., 2011) Amao (Amao et al., 2016) Bravo (Bravo-Escobar et al., 2017)	LVEF Endothelial function, HR, BP Heart function, ability to walk Quality of life	It is applicable to a wide range of people; however, it is expensive and time consuming for patients, leading to low patient compliance.
Home-based CR	Chen (Chen et al., 2018) Saygin (Saygin et al., 2018) Frontera (Frontera et al., 2017a) Fang (Fang et al., 2019) Liu (Liu et al., 2013) Vieira (Vieira et al., 2018)	VO2max, AT, quality of life Walking distance, anaerobic value, LVEF, VO2max Remote electrocardiogram Remote sensors Sports bracelet Virtual reality technology	It is not limited by space and time, is easy to integrate into the patient's life, is convenient, and has a low cost; however, more studies are needed to verify its training effect. In addition, it is only applicable to patients with low to medium rehabilitation risks.
Other forms of CR (multifactorial individualized telemedicine, remote health-care focusing on exercise or recovery, and community CR)	Dorje (Dorje et al., 2018)	Walking distance, medication adherence, mental health, quality of life	These models can reduce the risk factors of CHD, the difficulty due to inconvenient transportation, and the economic burden on patients.

CR: cardiac rehabilitation, LVEF: left ventricular ejection fraction, HR: heart rate, BP: blood pressure, VO2max: maximal oxygen consumption, AT: anaerobic threshold, CHD: coronary heart disease.

ously adjust and optimize the rehabilitation treatment models according to relevant factors that affect patient compliance and benefit more patients with CHD.

2. Treatment models of CR

For patients with CHD, CR is not only a supplement to treatment, but also a continuation of treatment (Anchah et al., 2017). CR can be divided into three stages: the first stage begins during hospitalization and consists of early mobilization, assessment, and rehabilitation guidance. The second stage is the outpatient rehabilitation period (2-6 weeks after discharge) (Di et al., 2017). Based on the cardiopulmonary function evaluation of patients, individualized exercise prescription is formulated to guide patients in participating in regular rehabilitation exercise in the hospital, while lifestyle and drug treatment are managed simultaneously. The third stage is the community or home-based rehabilitation period where the main purpose was to consolidate the rehabilitation effect of the second stage and help patients adopt a healthier lifestyle that would provide a safer exercise environment (Astley et al., 2017). The existing treatment models and the characteristics of previous studies are shown in (Table. 1).

2.1 Hospital-based CR

The effect of this model in improving the health-related quality of life and psychological status, as well as reducing the readmission rate has been established. Kim et al. revealed that in patients with CHD, the left ventricular ejection fraction was significantly improved and mortality rates were significantly reduced after hospital-based CR for 6 months (Kim et al., 2011). Martinez et al. reported that CR can improve vascular endothelial function,

lower heart rate, and reduce blood pressure (Martinez et al., 2011). Amao et al. found that early implementation of hospital-based CR can be an effective way to successfully improve the function of mechanical circulatory support in children after follow-up of a 6-year-old child with fulminant myocarditis (Amao et al., 2016). The child underwent CR after using an *in vitro* left ventricular assist device for 2 days. Although the child had hemiplegia due to a stroke, she was able to walk a distance of 280 m after 127 days of CR. Moreover, the child's heart function improved enabling successful heart transplantation. Simultaneously, early hospital-based CR can also be used as a bridge to heart transplantation; however, it has been used sparingly for a variety of reasons such as family economic restrictions and transportation difficulties.

2.2 Home-based CR

Advances in economic growth and telemedicine technology have allowed CR to be performed in the patients' home. This model of rehabilitation is not limited by space and time and has been performed gradually in Western countries. Foreign studies have found that home-based cardiac telerehabilitation is more effective than hospital-based CR in maintaining the exercise capacity of patients that it can improve the participation rate of patients in remote areas and of elderly patients with CHD, and that it is more convenient and has lower treatment cost than hospital-based CR (Bravo-Escobar et al., 2017). In the study by Chen et al, home-based CR resulted in a statistically significant improvement in VO2max, anaerobic threshold, and quality of life (Chen et al., 2018). Saygin et al. studied 35 patients with a history of myocardial infarction who underwent CR for 1 month and observed

no significant difference between home-based and hospital-based CR. Results were evaluated with the 6-minute walking test, upper-limb arm force test, and anaerobic exercise test with exception for improvements in ejection fraction and oxygen peak (Saygin et al., 2018). Therefore, home-based CR can be used as an effective alternative model to CR performed in hospitals and other healthcare centers, especially among disabled and elderly patients and those living in rural areas. In addition to its benefits, a further advantage of home-based CR is its easy integration and lower impact into the patients' daily life.

Home-based rehabilitation programs; however, have not been widely popularized in China because the corresponding intervention measures and monitoring methods are different. Frontera et al. used remote electrocardiography to monitor patients with ischemic heart disease with a moderate cardiovascular risk, and found that home-based CR is as effective as hospital-based CR after 8 weeks of intervention (Frontera et al., 2017b). Fang et al. (Fang et al., 2019) used remote sensors to implement home-based cardiac telerehabilitation for real-time monitoring and rapid feedback with respect to the patient's physical activity. Liu et al. used a sports bracelet for remote monitoring in a home-based cardiac telerehabilitation program and observed a significant improvement in the home-based CR group compared to the conventional group in terms of heart function and exercise endurance (Liu et al., 2013). For the specific implementation of exercise programs, Vieira et al. (Vieira et al., 2018); who came from the Abel Salazar Institute of Biomedical Sciences, University of Porto, Portugal, applied virtual reality technology (Kinect) for real-time evaluation and feedback. Their results showed a statistically significant improvement in executive function, especially selective attention and conflict resolution, in the intervention group compared to the control group where an exercise program was implemented using the traditional brochure format.

There are certain limitations in home-based CR. This model is only applicable to patients with low to medium rehabilitation risks (Saygin et al., 2018). Moreover, as it is conducted in the home environment, professional rehabilitation therapists and nurses are required to provide regular exercise guidance, telecommunicate, and conduct patient follow-ups in order to address doubts, misunderstandings, or potential affective disorders in the performance of physical exercise. This poses a greater challenge in the sense of responsibility and patience for the medical staff and in the management of nursing services for the hospital. Simultaneously, to ensure the safety of exercise and prevent accidents, the patient needs to be accompanied by a family member while performing the exercise.

2.3 Other forms of CR

The great challenges to the traditional hospital-based CR model, such as high cost and long therapy time, result in low compliance of patients to CR (Frontera et al., 2017b). These challenges have led to the development of alternative CR models in recent years that include multifactorial individualized telemedicine, remote healthcare focusing on exercise or recovery, and community CR. Dorje et al. applied an interactive CR model based on smartphones and social media in 300 patients with CHD (Dorje et al., 2018). After 12 months of intervention, they observed a sig-

nificant improvement in the intervention group when compared with the conventional group in terms of 6-minute walking distance, medication adherence, mental health, and quality of life. Community CR and individualized telemedicine are effective alternatives to hospital-based CR, as they can also reduce the risk factors of CVDs, the difficulty of inconvenient transportation, and the economic burden on patients. Therefore, patients can choose the rehabilitation model according to their own needs, risks, and preferences.

3. Patient compliance to CR

Presently, the overall participation and compliance rates of foreign patients to CR are not high with the participation rate in the United Kingdom (UK) and the United States being only around 20% (Pavy et al., 2013). After investigating 2096 patients with acute myocardial infarction in 19 regions in the United States, Humphrey et al. found that the participation rate to CR was < 30% after 1 month (Humphrey et al., 2014). A follow-up study on 288,123 patients who underwent CR conducted by the UK CR audit office found that only 13% of the patients completed CR in 8 weeks (Sumner et al., 2016). Although the clinical significance of CR has been recognized by most countries, the participation of patients is still low. Moreover, the implementation of CR has just begun in domestic tertiary hospitals in general and in urban tertiary hospitals in particular.

4. Relevant factors affecting patient compliance to CR

4.1 Healthcare system factors: hospital referral system

As the economic development of China is presently unbalanced, it is difficult to build a complete nationwide rehabilitation system. The identification of patients who are suitable for CR and can benefit the most from the intervention is based on standard referrals. Owing to the imperfect referral system and related cognitive factors, the referral rate of patients is very low. Beatty et al. found that the referral rate was only 48% after investigating 71,556 patients with CHD who were suitable for CR in Washington, DC (Beatty et al., 2017). According to 2014 data, the referral rate of CR in patients with CHD was only 52% in Canada, 56-60% in the United States, and only 7.3% in Turkey (Turk-Adawi et al., 2014; Dunlay et al., 2014). Currently, there is no report on the referral rate of CR in China. Therefore, hospitals should properly and effectively manage the CR referral system, consider referral as a part of medical care, and assign special personnel who will supervise and inspect the enforcement of referrals to avoid omission and eliminate obstacles.

4.2 Healthcare system factors: rehabilitation models

Presently, hospital-based CR is the main rehabilitation model with low patient compliance for various reasons including the remoteness of the CR center, long time required for rehabilitation, inconvenience of traffic disruption, and potential conflict between rehabilitation and work time (Chen et al., 2018). Bravo et al. found no statistical difference between hospital-based and home-based CR in terms of the quality of life of patients with CHD (Bravo-Escobar et al., 2017). Further studies are needed in the future to verify these conclusions. A multifactorial individualized re-

mote rehabilitation medical model has also achieved good results (Grace et al., 2016). Hospitals should integrate various rehabilitation treatment models according to the individual conditions of patients and the existing cardiovascular risk factors. Simultaneously, patients can select the appropriate rehabilitation model according to individualized needs.

4.3 Healthcare system factors: medical staff

Because medical staff have an insufficient understanding of the impact of CR and attach little attention to this intervention, they cannot provide reasonable guidance and advice to patients about the significance and importance of CR. After investigating the current knowledge and practice of CR among 289 nurses in the department of cardiology at 4 hospitals in ShengZhou, Liu et al. found that the nursing staff had a positive attitude and standardized behavior toward CR training in patients with CHD, but lacked the relevant knowledge needed to implement the training (Suhua et al., 2015). Therefore, hospital managers should strengthen the CR training and education programs for medical staff, to inform them about the significance of CR. This will help medical staff to dedicate more attention to CR and ensure that each patient receives adequate and authoritative information that they can benefit from CR. Furthermore, CR requires additional manpower and resources, and its social benefits are long-term rather than immediate. This causes difficulty for many patients adhering to CR for an extended period of time. Therefore, medical staff should strengthen their communication with patients to understand their confusion and doubts and to encourage them to actively participate in CR.

4.4 Patient factors: age

Doll et al. (Doll et al., 2015) showed that elderly patients had low CR compliance because some mistakenly believe that CR involves mechanical and painful activities, which would not be conducive to improving health. At the same time, elderly people have more health problems, lower physical functioning, and complications than younger individuals. As a result, they benefit significantly less from CR than younger people. However, other studies found that young people have a limited time for CR because of conflicts between the time for CR and the time for work (Galati et al., 2018). In addition, young patients pay less attention to CR because they consider themselves to have strong recovery ability, whereas elderly patients pay more attention to health problems. Therefore, further studies are necessary to explore the impact of age on the compliance to CR of patients with CVD. Simultaneously, it is suggested that health managers should take different health education measures according to the patients' age and emotional problems to help patients realize the importance of CR and encourage them to consciously and actively participate in the intervention.

4.5 Patient factors: sex

Mosca et al. found that the compliance of female patients was lower than that of male patients because women were more likely to have a variety of coexisting diseases such as osteoporosis and muscle weakness (Mosca et al., 2011). This reduced the patients' compliance of CR to some extent. Colbert et al. conducted a retrospective study in 25,958 patients with CHD and found that the referral and completion of CR in female patients was lower

than those in male patients (Colbert et al., 2015). Samayoa et al.; however, found that female patients who underwent rehabilitation with different CR models had better CR adherence (Samayoa et al., 2014). Kim et al. found no difference in CR participation between female and male patients after a follow-up of 144 patients with CHD undergoing 9 months of home-based CR (Kim and So, 2019). The high-density lipoprotein cholesterol levels were increased in male patients after the program. Health variables such as cardiovascular endurance, strength, and agility improved significantly, whereas most risk factors and health variables did not significantly differ in women. This affected the female patients' confidence and determination to participate in CR. Therefore, the effect of sex on CR compliance needs to be further verified. Female patients have more psychological vulnerabilities. Moreover, the physical recovery of female patients is worse than that of male patients, which makes female patients more prone to emotional problems such as anxiety and depression. As a result, more attention and social support should be given to female patients undergoing CR.

4.6 Patient factors: health knowledge level

Sandesara et al. showed that patients with higher levels of health knowledge have higher adherence to CR (Sandesara et al., 2015). The reasons may be that these patients are more aware of the importance of CR and have a stronger motivation and positive mentality, which make them more confident about CR treatment and its potential to reduce cardiovascular risk factors through lifestyle changes. Therefore, these patients are more likely to achieve the desired effect of CR. The treatment of CHD is a long process that requires patients to use drugs for a long time or even throughout their lifetime. As a result, patients easily lose confidence and patience about the effects of rehabilitation (Mosca et al., 2011). Patients with higher health knowledge can face life difficulties with a more optimistic attitude allowing them to overcome negative emotions. Therefore, to improve patient compliance, medical staff should give more attention and psychological support to patients with a low level of health knowledge to improve cognitive performance and continuously influence behavior toward health management and lifestyle.

4.7 Race and ethnicity factors

In a systematic review published in 2019, a disparity between non-white and white patients in terms of CR referral and participation was identified (Castellanos et al., 2019). Gregory et al. reported a higher referral rate for white patients than for non-white patients (Gregory et al., 2006). However, Beatty et al. reported that there was no difference in CR referral between non-white and white patients in hospitals with high CR referral rates (> 85%) (Beatty et al., 2018). Furthermore, studies that included racial and ethnic groups have revealed that the inability to speak English was a strong indicator of low CR referral rates for minority patients (Brady et al., 2013). In general, the referral rates are significantly higher for the general population and for white patients than for non-white patients. Therefore, educational programs that target healthcare provider biases toward racial and ethnic groups may contribute to further increasing the referral and participation rates to CR.

4.8 Other factors

CR has been shown to improve the quality of life and decrease subsequent morbidity and cardiovascular mortality by approximately 20% (Anderson et al., 2016). However, it was estimated that only 30% of eligible patients participate in CR (Beatty et al., 2018). Such underutilization can be partly attributed to low referral rates by healthcare providers (Beatty et al., 2017). Among individuals referred for CR, few enroll in the program and eventually drop out (Brady et al., 2013). In addition to the above-mentioned reasons for the low compliance of patients, there are many other factors influencing the utilization of CR including work and other time constraints, distance, financial resources, social support, illness perceptions, and depression (Resurrección et al., 2018). A systematic review and meta-analysis published in 2019 showed that a number of different interventions can increase patient compliance to CR. Among them, the most effective way to improve CR utilization is through face-to-face interventions provided by healthcare providers (Pio et al., 2019). In addition, offering unsupervised CR sessions may promote greater adherence (Beatty et al., 2017). More studies are needed in the future to specifically understand how to increase CR utilization and to establish implementable and specific intervention protocols.

5. Strategies to increase patient referral and long-term participation in CR programs

(1) Incorporate outpatient CR into the discharge plan. After discharge, patients can obtain strong endorsement of outpatient CR by hospital administration and referring physicians. Medical institutions automatically refer all eligible patients to outpatient CR upon discharge. Patients with low to moderate risk are offered options for home-based CR programs at discharge.

(2) Before patients are discharged from the hospital, the physicians should take the initiative to provide CR information and education to inpatients. Produce a brief (7-10 min) promotional video about the value of outpatient CR that can be demonstrated to patients during inpatient rehabilitation.

(3) Provide patients with the contact information of the outpatient CR center closer to their home. The staff of the rehabilitation center can arrange patients to make CR registration and appointment via their preferred means of communication (text message, telephone call, email or ordinary mail).

(4) Consider financial incentives at the system, provider and patient levels to encourage referrals, participation and completion of early outpatient based CR courses.

(5) Target specific patient subgroups that are least likely to participate in and complete CR (such as ethnic minorities, women, the elderly, rural residents and individuals with poor economic conditions) via diversified networks.

(6) Develop a series of integrated practice units of allied health professionals that can provide consulting services via face-to-face visits or through web-based and mobile applications, handheld computer technologies, telephone counselling, or the Internet (Thomas et al., 2019).

(7) Exercise prescription was made for patients according to their physical conditions and exercise dose and compliance were taken as measures to ensure CR quality (Morris et al., 2019).

(8) Provide a series of assessments to track ongoing efforts to reduce cardiovascular risk, including physical activity/fitness training (Freeman et al., 2019).

6. Summary and outlook

With the development of society and improvement of living standards, the prevalence of CHD is increasing. Numerous studies have demonstrated the importance of CR in preventing and treating CHD. Reasonable CR training and secondary prevention can reduce the mortality rate of CVDs by 20-30% (Fang et al., 2019). However, studies on the mechanism of CR are incomplete, and the model and method of rehabilitation needs to be further standardized and improved. At the same time, the development of CR in China still faces many challenges (Dorje et al., 2018). The existing biomedical model has been focused on therapy, with little attention to prevention and to the follow-up of treated patients. The efficacy of therapy; however, is highly dependent on post-therapy recovery. Moreover, most medical staff and patients are not aware of the significance of CR (Suhua et al., 2015), which hinders the development of CR. Presently, CVDs have a high incidence and patients with CVD are becoming younger while the population is rapidly aging (Kozela et al., 2019). Therefore, society should pay more attention to the research and development of CR.

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Conflict of Interest

The authors declare no competing interest.

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