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Article

Effects of Phase I Cardiac Rehabilitation Combined with Cognitive Behavioural Therapy on Cardiac Function, Exercise Capacity and Mental Health in Patients after Aortic Valve Replacement: A Retrospective Study

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Abstract

Objective: To explore the application effect of phase I cardiac rehabilitation (CR-I) combined with cognitive behavioural therapy (CBT) on patients after aortic valve replacement (AVR). **Methods**: This study retrospectively analysed the data of 441 patients after AVR in our hospital from January 2020 to May 2023. A total of 38 patients who did not meet the inclusion criteria were excluded. A total of 403 patients were included. In accordance with different postoperative management schemes, the included patients were divided into the reference group (n = 202, received CR-I) and the observation group (n = 201, received CR-I+CBT). The cardiac function, exercise capacity and mental health of the two groups were compared. **Results**: Before management, both groups had no significant differences in left ventricular end diastolic diameter (LVEDD), left ventricular end systolic dimension (LVESD), left ventricular ejection fraction (LVEF) and six-minute walking test (6MWT) scores ($p > 0.05$). At discharge and 3 months after discharge, the observation group had significantly lower LVEDD and LVESD and remarkably higher LVEF and 6MWT scores than the reference group ($p < 0.001$). The proportions of autonomous activity in bed within 3–4 days after surgery, autonomous out-of-bed activity within 8–10 days after surgery and autonomous walking 200 m within 12–15 days after surgery were distinctly higher ($p < 0.001$) and the incidence of adverse reactions was overtly lower ($p < 0.001$) in the observation group than in the reference group. Before management, both groups had no significant difference in their scores on the State-Trait Anxiety Inventory (STAI) ($p > 0.05$). At discharge and 3 months after discharge, the observation group had lower STAI scores than the reference group ($p < 0.001$). **Conclusion**: CR-I combined with CBT effectively improves the cardiac function, independent exercise capacity and mental health level of patients after AVR and provides a new direction for the formulation and selection of follow-up clinical management.

Keywords

phase I cardiac rehabilitation; cognitive behavioural therapy; aortic valve replacement; cardiac function; exercise capacity; mental health

Introduction

In China, the prevalence of cardiovascular diseases continues to rise with the rapid increase in the ageing population [1]. Valvular heart disease accounts for 1/3 of all heart diseases, and its prevalence is gradually increasing under the influence of population ageing, population growth and advancements in diagnostic techniques [2]. Common aortic valve diseases in clinical practice include aortic stenosis and incompetence. As the severity of valve diseases gradually increases, patients often experience chest pain, fatigue, asphyxia and heart failure. These symptoms affect daily life, reduce quality of life and even seriously threaten life safety if left untreated [3]. Aortic valve replacement (AVR) is a rapidly developing technology and a mature treatment option for patients with symptomatic severe aortic stenosis [4]. Given that the population receiving AVR treatment is mostly comprised of the elderly with various physical functions in decline, surgical treatment alone is insufficient to improve the quality of life of patients. In addition, elderly patients receiving AVR treatment usually have multiple comorbidities [5] that are accompanied by an increased risk of postoperative complications after surgery and a decline in physical function during the postoperative recovery period [6]. Therefore, studying strategies to improve the health outcomes of AVR is particularly important.

Cardiac rehabilitation (CR) is a rehabilitation programme that consists of education, exercise and risk factor intervention; its core components include patient assessment, nutritional counselling, cardiovascular risk factor management, exercise training and physical rehabilitation counselling [7], as shown in Fig. 1. Phase I CR (CR-I),

the first phase of this rehabilitation programme, is administered in the hospital during or after cardiac events to improve early exercise capacity [8]. Cognitive behavioural therapy (CBT) is a type of psychological therapy that has been proven to be effective in treating mental illnesses [9]. It is mainly used in the treatment of mental diseases, such as anxiety and depression, and is increasingly used in psychosocial intervention programmes to modify cardiovascular risk factors and reduce psychosocial risk factors, such as depression, anxiety and loneliness, in patients with heart disease [10]. At present, only a few studies on the application of CR combined with CBT in patients after AVR have been conducted. Therefore, this study aims to elucidate the effect of this combined intervention on patients after AVR from the perspectives of cardiac function, exercise capacity and mental health.

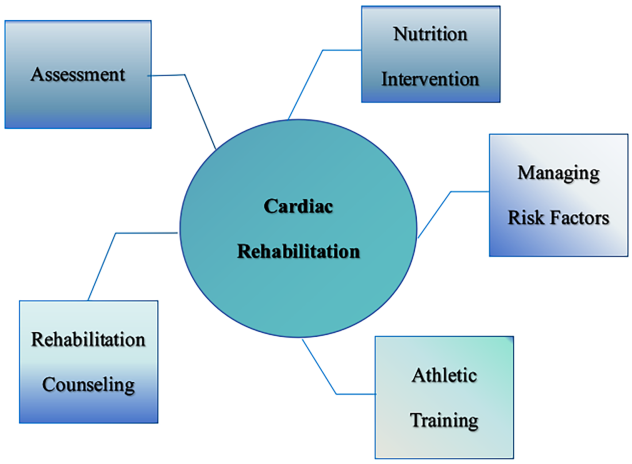

Fig. 1. Core components of cardiac rehabilitation (CR).

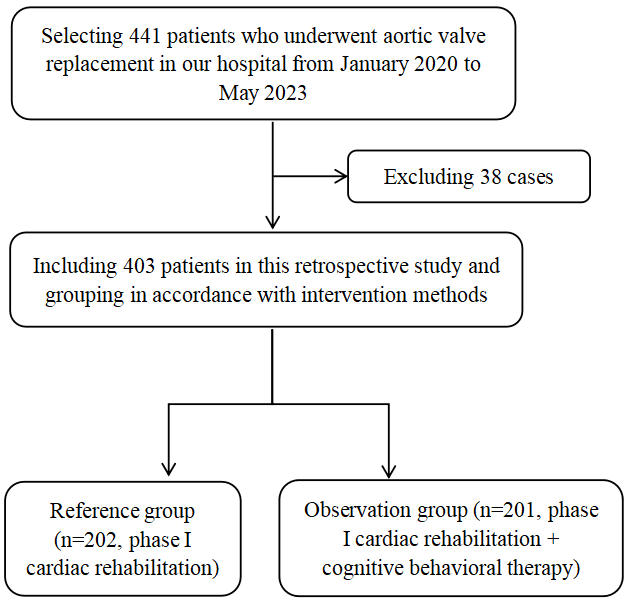

Fig. 2. Study design.

Materials and Methods

Research Subjects

This work is a single-centre retrospective study that included 441 patients who underwent AVR in our hospital from January 2020 to May 2023.

Inclusion criteria. (1) Patients aged ≥18 years old with normal communication ability. (2) Patients with complete pathological data and medical records. (3) Patients in stable condition without serious postoperative complications, such as perivalvular leakage, fatal arrhythmia, severe low cardiac output syndrome (characterised by decreased cardiac output and insufficient peripheral perfusion), respiratory failure and severe renal dysfunction.

Exclusion criteria. (1) Patients with missing medical records. (2) Patients who developed severe postoperative complications and required further treatment. (3) Patients with complications affecting exercise endurance or musculoskeletal diseases. (4) Patients with a history of mental illness.

After screening, 38 patients who did not meet the inclusion criteria were excluded (7 cases with musculoskeletal diseases, 5 cases with a history of mental illness, 10 cases with severe postoperative complications, 12 cases with complications affecting exercise endurance and 4 cases without clinical data), and 403 patients were finally included (the study design is shown in Fig. 2). Given that this research is a retrospective study, obtaining the informed consent of patients was unnecessary.

Methods

Reference Group

The reference group received CR-I. The detailed intervention steps are shown in Table 1.

Observation Group

The observation group received CR-I and CBT. The CR-I method is the same as that that described Table 1, and the implementation steps of CBT are shown in Table 2.

Observation Indicators

Baseline Characteristics

The baseline data of gender, age, body mass index, cardiac functional grading, disease cause, combined diseases, educational levels and occupation were compared between the two groups.

Table 1. CR-I intervention steps.

Steps	Concrete contents
Evaluation and monitoring	The past medical history, daily lifestyle, exercise habits, vital signs and cardiopulmonary function of the patients after surgery were evaluated to lay a foundation for the formulation and implementation of the rehabilitation plan.
Breathing training	After the patients were transferred from the intensive care unit to the general ward, abdominal breathing training on the bed was given under electrocardiographic monitoring for 3 times/day and 15–20 min/time. The abdominal breathing exercise involved bulging the stomach for 3–5 s during deep inspiration, holding the breath for 1 s, slowly exhaling, shrinking the stomach for 3–5 s and holding the breath for 1 s after retraction. Postoperative labial breathing training was provided 3 times/day for 15–20 min/time. It involved taking a deep breath, inhaling air into the lungs through the nasal cavity, holding for 1–2 s, slowly inhaling the nasal air into the throat, pursing the lips as if whistling and puffing up the cheeks to exhale outward slowly for 3–4 s for as long as possible. The patients were instructed to perform blow balloon training for 2 times/day and 15–20 min/time. The patients were treated with the active cycle of breathing technique. During the training, the patients were knocked on the chest to induce vibration suction for 2 times/day and 10 min/time.
Exercise training	During postoperative days 1–2, the patients were instructed to conduct active and passive limb activities in the supine position for 3–5 times/day and 10–15 min/time. These activities included flexion; the introversion and external rotation of the wrist, elbow, ankle and knee; and hand grasping exercises. During postoperative days 3–4, the patients were instructed to perform an exercise for strengthening the lower limbs in sitting position on the basis of the activities in supine position. For example, the patients sat on the edge of the bed, with both lower limbs naturally drooping, alternately swinging from side to side and simultaneously swinging back and forth for 2–3 cycles/day, 10–15 min/cycle and 50 times/cycle. On the premise that the patients could stand during postoperative days 5–6, the upper limb exercise was performed on the basis of the previous training, and upper limb pulling and lifting movements, such as hair combing, were added. If the patients can get out of bed, they can stand at their bedside for 2–3 times/days and 10–15 min/time; gradually perform the bedside step training for 20–30 steps/time and 2–3 times/day; and gradually walk independently in wards for approximately 30–100 m and 2–3 times/day. From postoperative day 7 to discharge, the patients were guided to walk 100–150 m independently in the corridor for 2–3 times/day. On the basis of daily walking, warm-up exercise and stair walking training were gradually added (gradually increased from one flight of stairs for 1 time/day). If chest tightness, nausea, vomiting, dizziness and other discomfort occurred during exercise, the activity was immediately stopped.
Close observation	The condition of the patients was observed at any time during the postoperative exercise. If the patients experienced chest tightness, chest pain, breathing >30 beats/min, exercise heart rate exceeding resting heart rate by 20% and blood oxygen saturation <95%, the activities were immediately stopped and electrocardiogram monitoring was performed using electrocardiogram equipment. When the patients' condition was stable, the next stage of exercise training was performed in accordance with the patient's specific situation.
Health education	The medical staff explained to the patients the importance of postoperative breathing exercise and exercise training for CR and guided the patients on the accurate performance of comprehensive breathing exercises, exercise training and CR training. The medical staff described the relevant training methods in detail before the patients were discharged and advised the patients to continue exercise, such as tai chi, cycling and jogging, after discharge in accordance with personal circumstances. The patients should pay attention to exercise intensity to avoid discomfort.

Cardiac Function

(1) Cardiac function indices. The left ventricular end diastolic diameter (LVEDD), left ventricular end systolic dimension (LVESD) and left ventricular ejection fraction (LVEF) in the two groups were measured by using a Philips IU-22 colour Doppler ultrasound instrument (manufacturer: Royal Dutch Philips Electronics Ltd.; origin: Netherlands). The results of the two groups before management, at discharge and 3 months after discharge were compared and evaluated.

(2) Six-minute walking test [11]. The six-minute walking test (6MWT) was performed for assessment before management and at discharge. The patients wore comfortable clothes and shoes and used common walking aids to

Table 2. CBT implementation steps.

Steps	Concrete contents
Establishment of good relationship	The medical staff actively communicated with the patients and their families, and actively established a good cooperative relationship with the patients and their families to increase their trust. For example, health education on postoperative nursing and attention matters should be provided to patients in the form of oral narration, health manuals and video publicity.
Initial assessment	The medical staff performed face-to-face communication with the patients to evaluate the patients' cognition of CR-I after surgery. They guided the patients to express their true ideas, such as unwillingness to conduct rehabilitation training due to fear of postoperative wound pain, worries about disease recurrence during postoperative training, or feeling that the content of rehabilitation training was too complicated. Moreover, they instructed patients to talk about planning for disease control. Through clinical trials, medical staff recorded, analysed and identified the patients' one-sided views and wrong thinking and encouraged the patients to record their true thoughts.
Cognitive reconstruction	The medical staff guided the patients to summarise all their thoughts after surgery; found evidence with the patients to overturn their original negative thoughts and false cognition; and instructed the patients to focus on other aspects of life and distract their attention. For example, medical staff guided patients to subscribe to the Wechat official account of the department, to strengthen patients' cognition of aortic valve replacement by providing related knowledge about disease, surgery and postoperative behavior management. The medical staff explained the importance of postoperative CR training and the value of postoperative body recovery in the form of pictures, texts and videos to improve the patients' cognition, and consciously develop a good healthy lifestyle, such as smoking cessation, drinking cessation, low-salt and low-fat diet, regular work and rest habits. By imaginative aversion therapy, the patients were guided to imagine the effect of negative emotions on postoperative exercise, correct their poor behaviour and increase their enthusiasm for postoperative CR training. Through muscle relaxation therapy, mindfulness therapy and meditation, the patients were instructed to feel the processes of muscle contraction and relaxation, gradually reduce the muscle response, relax the body and mind, and arouse the muscle control. The patients were guided to keep an intervention diary, mainly recorded the activities that affected the disease on the day, the measures to correct bad habits, as well as the physical and mental changes.
Feedback assessment	After 1 week of cognitive reconstruction, the medical staff guided the patients to review the postoperative rehabilitation training steps and gain a detailed understanding of their current problems; judged whether to increase the number or duration of communication in accordance with the patients' specific situation; and corrected the patients' wrong cognition to consolidate core beliefs. At the same time, regular patient gatherings were organized to allow patients to communicate with each other and share their own personal treatment experiences, so as to strengthen their own healing beliefs and provide treatment confidence for others.

walk on flat ground. Before testing, the patients rested in the starting chair for at least 10 min and then walked as fast as possible for 6 min without running or jogging. When they experienced difficulty breathing or exhaustion, they could slow down and rest against the wall if necessary (timing was not stopped during resting) and then resume walking as soon as possible.

Exercise Capacity

(1) Postoperative autonomous activity. The proportions of autonomous activity in bed within 3–4 days after surgery, autonomous out-of-bed activity within 8–10 days after surgery and autonomous walking for 200 m within 12–15 days after surgery in the two groups were statistically compared.

(2) Incidence of adverse reactions during autonomous activity. The proportions of adverse reactions (chest pain, chest tightness, palpitations and dizziness) during postoperative autonomous activity in the two groups were statistically compared.

Mental Health

The State-Trait Anxiety Inventory (STAI) [12] was used to evaluate and compare the psychological status of the patients in both groups before management, at discharge and 3 months after discharge. STAI is divided into the State Anxiety Inventory (S-AI) and Trait Anxiety Inventory (T-AI), with a total of 40 items, all of which were scored from 1 to 4. The scores of each questionnaire ranged from 20 to 80 points. A high score is indicative of severe anxiety.

Table 3. Comparison of baseline characteristics between groups.

Items		Reference group (n = 202)	Observation group (n = 201)	χ^2/Z	*p*
Gender	Male	105 (51.98)	107 (53.23)	0.064	0.801
	Female	97 (48.02)	94 (46.77)		
Age (years)		57.00 (47.00, 64.00)	56.00 (48.00, 63.50)	−0.018	0.986
Body mass index (kg/m^2, M [P_{25}, P_{75}])		23.00 (22.20, 23.73)	23.00 (22.05, 23.90)	−0.280	0.779
Cardiac functional grading	Grade II	109 (53.96)	114 (56.72)	0.310	0.578
	Grade III	93 (46.04)	87 (43.28)		
Disease cause	Aortic stenosis	111 (54.95)	105 (52.24)	0.344	0.842
	Aortic incompetence	67 (33.17)	72 (35.82)		
	Aortic stenosis and incompetence	24 (11.88)	24 (11.94)		
Combined diseases	Hypertension	56 (22.72)	59 (29.35)	0.160	0.984
	Diabetes	44 (21.78)	44 (21.89)		
	Hyperlipidaemia	37 (18.32)	36 (17.91)		
	No	65 (32.34)	62 (30.69)		
Educational levels	Junior high school and below	68 (33.66)	74 (36.82)	0.515	0.773
	Senior high school	95 (47.03)	92 (45.77)		
	University and above	39 (19.31)	35 (17.41)		
Occupation	Employment	114 (56.44)	109 (54.23)	1.382	0.501
	Retirement	35 (17.33)	44 (21.89)		
	Unemployment	53 (26.24)	48 (23.88)		

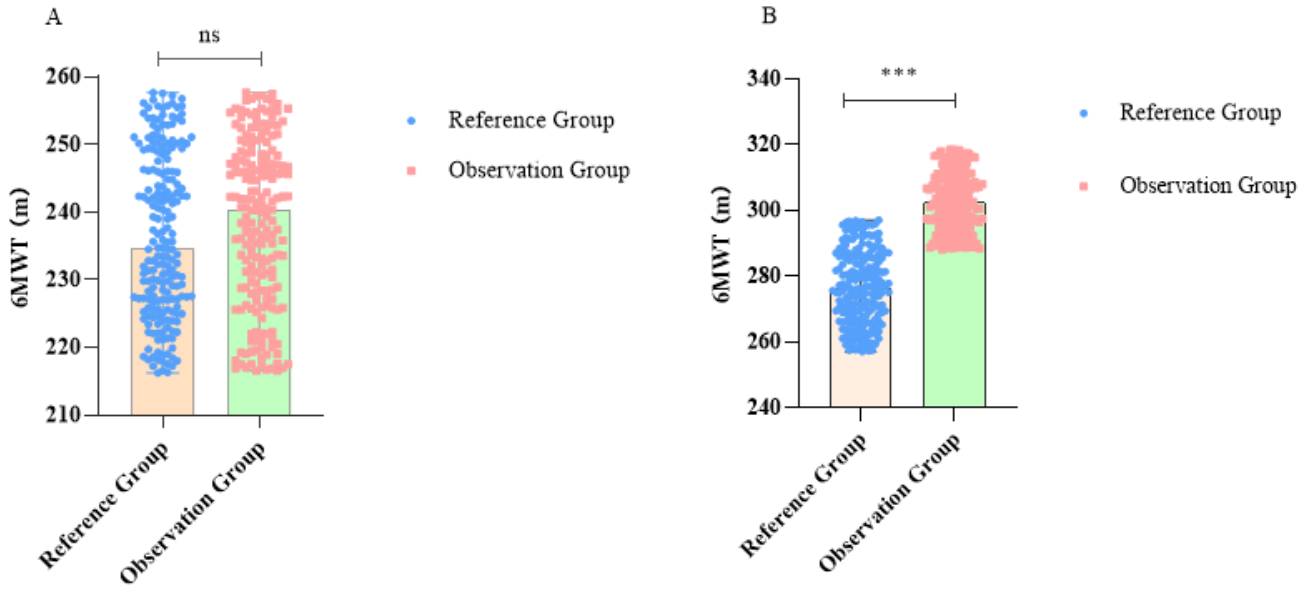

Fig. 3. Comparison of 6MWT between groups. Notes: 6MWT, Six-minute walking test; ns, $p > 0.05$; ***, $p < 0.001$.

Statistical Methods

This study adopted SPSS (version: 27.0; manufacturer: International Business Machines Corporation; origin: Armonkdainty, NY, USA) to analyse and process data. The categorical variables in the data were subjected to χ^2 test and expressed as n (%). The Shapiro–Wilk method was used to test whether the continuous variables conformed to the normal distribution. The data that did not conform to the normal distribution were subjected to Mann–Whitney U test and expressed as M (P_{25}, P_{75}). Differences were statistically significant when $p < 0.05$. Figs. 1,2 were drawn by using WPS Office Word (version: 2021; manufacturer: Kingsoft Co., Ltd.; origin: Beijing, China), Fig. 3 was drawn by using GraphPad Prism (version: 7.0; manufacturer: GraphPad Software; origin: San Diego, CA, USA) and Fig. 4 was drawn by using WPS Office Excel (version: 2021; manufacturer: Kingsoft Co., Ltd.; origin: Beijing, China).

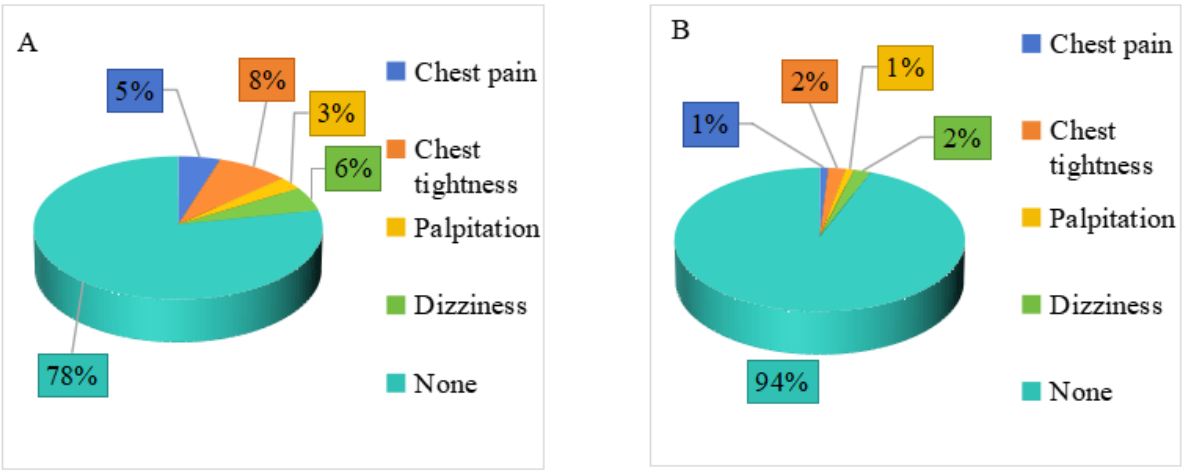

Fig. 4. Comparison of adverse reactions during autonomous activity between groups. Notes: Fig. 4A represented the incidence of adverse reactions during the autonomous activity in the reference group; Fig. 4B represented the incidence of adverse reactions during autonomous activity in the observation group.

Results

Comparison of Baseline Characteristics between Groups

Both groups had no significant difference in gender, age, cardiac functional grading, disease cause, combined diseases, education levels, and occupation ($p > 0.05$), as shown in Table 3.

Comparison of Cardiac Function Indices between Groups

Before management, LVEDD, LVESD and LVEF did not significantly differ between groups ($p > 0.05$). At discharge, the medians of LVEDD, LVESD and LVEF in the reference group were 48.65 mm, 55.43 mm and 51.00%, respectively. The medians of those in the observation group were 42.16 mm, 51.79 mm and 55.00%, respectively. The observation group had significantly lower LVEDD and LVESD and significantly higher LVEF than the reference group, with statistically significant difference ($p < 0.001$).

At 3 months after discharge, the medians of LVEDD, LVESD and LVEF in the reference group were 43.53 mm, 53.78 mm and 54.00%, respectively. The medians of those in the observation group were 41.47 mm, 49.56 mm and 56.00%, respectively. Compared with the reference group, the LVEDD and LVESD of the observation group were significantly lower, and the LVEF was significantly higher. The difference between the groups was statistically significant ($p < 0.001$), as shown in Table 4.

Comparison of 6MWT between Groups

The 6MWT results between groups before management are shown in Fig. 3A. The 6MWT results in the reference group and the observation group were 234.75 (226.84, 248.05) m and 240.32 (228.45, 248.43) m, respectively. No statistical significance was found between groups ($Z = -1.552$, $p = 0.12$).

The 6MWT results between groups at discharge are presented in Fig. 3B. The 6MWT results in the reference group and the observation group were 276.18 (267.60, 286.34) m and 302.55 (295.72, 309.66) m, respectively. No statistical significance was found between groups ($Z = -16.292$, $p < 0.001$).

Comparison of Autonomous Activity and Adverse Reactions between Groups

As shown in Table 5, the observation group had a significantly higher rate of autonomous activity in bed within 3–4 days after surgery, autonomous out-of-bed activity within 8–10 days after surgery and autonomous walking for 200 m within 12–15 days (97.51%, 85.57%, 83.58%) after surgery ($p < 0.001$) than the reference group (78.22%, 68.81%, 64.36%).

As shown in Fig. 4A, the incidences of adverse reactions during autonomous activity in the reference group (21.78%), among which 17 patients had chest tightness, 10 patients had chest pain, 6 patients had palpitation, and 11 patients had dizziness. Fig. 4B indicates the incidences of adverse reactions during autonomous activity in the observation group (5.97%), among which 4 patients had chest tightness, 2 patients had chest pain, 2 patients had palpitation, and 4 patients had dizziness. Compared with the reference group, the observation group had significantly lower incidence of adverse reactions ($\chi^2 = 21.053$, $p < 0.001$).

Table 4. Comparison of cardiac function indices between groups (M [P_{25}, P_{75}]).

Groups	LVEDD (mm)			LVESD (mm)			LVEF (%)		
	Before management	At discharge	3 months after discharge	Before management	At discharge	3 months after discharge	Before management	At discharge	3 months after discharge
Reference group (n = 202)	52.66 (51.09, 54.26)	48.65 (47.17, 49.85)	43.53 (42.80, 44.30)	59.75 (58.95, 60.43)	55.43 (54.73, 56.24)	53.78 (53.01, 54.42)	48.00 (47.00, 50.00)	51.00 (49.00, 52.00)	54.00 (53.00, 55.00)
95% CI	52.456−52.922	48.397−48.814	43.405−43.649	59.564−59.811	55.308−55.536	53.611−53.830	47.882−48.435	50.328−50.811	53.369−53.681
Observation group (n = 201)	52.73 (51.27, 54.35)	42.16 (41.39, 42.16)	41.47 (40.73, 42.32)	59.59 (58.72, 60.32)	51.79 (50.36, 53.10)	49.56 (48.91, 50.10)	48.00 (46.00, 50.00)	55.00 (53.00, 56.00)	56.00 (55.00, 57.00)
95% CI	52.584−53.043	41.029−41.351	41.344−41.595	59.436−59.688	51.533−51.755	49.433−49.634	47.713−48.247	54.330−54.814	55.540−55.843
Z	−0.740	−17.364	−15.439	−1.373	−16.884	−17.364	−0.939	−15.488	−14.067
p	0.459	<0.001	<0.001	0.170	<0.001	<0.001	0.348	<0.001	<0.001

LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systolic dimension; LVEF, left ventricular ejection fraction.

Table 5. Comparison of autonomous activity between groups (n [%]).

Groups	Autonomous activity in bed within 3–4 days after surgery	Autonomous out-of-bed activity within 8–10 days after surgery	Autonomous walking for 200 m within 12–15 days after surgery
Reference group (n = 202)	158 (78.22)	139 (68.81)	130 (64.36)
Observation group (n = 201)	196 (97.51)	178 (85.57)	168 (83.58)
χ^2	35.118	17.305	19.329
p	<0.001	<0.001	<0.001

Table 6. Comparison of State-Trait Anxiety Inventory scores between groups (M [P_{25}, P_{75}], points).

Times	Indices	Reference group (n = 202)	Observation group (n = 201)	Z	*p*
Before management	S-AI	44.00 (41.00, 46.00)	44.00 (41.00, 46.00)	−1.122	0.262
	T-AI	44.00 (41.75, 47.00)	45.00 (42.00, 48.00)	−1.782	0.075
At discharge	S-AI	37.00 (35.00, 38.00)	32.00 (29.00, 34.00)	−15.620	<0.001
	T-AI	35.00 (33.00, 37.00)	30.00 (29.00, 31.00)	−17.027	<0.001
3 months after discharge	S-AI	30.00 (28.00, 31.25)	24.00 (23.00, 25.00)	−17.461	<0.001
	T-AI	33.00 (31.00, 34.00)	27.00 (26.00, 29.00)	−16.897	<0.001

S-AI, State anxiety inventory; T-AI, Trait anxiety inventory.

Comparison of STAI Scores between Groups

At discharge and 3 months after discharge, the observation group had significantly lower S-AI and T-AI scores than the reference group ($p < 0.001$), with statistical difference. However, before management, S-AI and T-AI scores did not significantly differ between groups ($p > 0.05$), as shown in Table 6.

Discussion

A number of clinical studies have shown that CR is an effective method for improving the physical function and survival rate of patients undergoing cardiac valvular surgery [13,14]. However, traditional CR focuses on exercise after AVR and pays little attention to the mental health of patients. AVR is a high-risk surgery, and patients experience fear, fatigue, anxiety, poor sleep quality, pain, depression and other conditions before and after AVR [15]. Under the influence of multiple factors, the postoperative compliance of patients in terms of medication adherence, dietary intervention, weight control, exercise and lifestyle changes may decrease. Treatment adherence is the basic element of the postoperative management of cardiac valve replacement. If patients do not follow a scientific rehabilitation program, the effect of surgical treatment will be seriously influenced [16]. Butz *et al*. [17] found that early cognitive training after cardiac valvular surgery has a considerable effect on improving health-related quality of life after surgery. The present study retrospectively analysed the effect of the combination of CR-I and CBT on AVR surgery. Its results are analysed below.

CR-I and CBT Significantly Improve the Cardiac Function of Patients after AVR

The results of this study showed that the observation group had significantly lower LVEDD and LVESD and significantly higher LVEF and 6MWT scores at discharge and 3 months after discharge than the reference group ($p < 0.001$). CR-I is a necessary link in CR and an important link in promoting cardiac function rehabilitation, which depends on the patients' initiative for implementation. Some patients undergoing cardiac surgery experience certain negative emotions [18] and are reluctant to cooperate with clinical rehabilitation training actively. This situation makes performing postoperative rehabilitation treatment difficult and affects disease rehabilitation. Cognitive behavioural theory holds that cognition regulates emotion and behaviour. Under stress conditions, individual emotional changes induce cognitive bias, and unreasonable cognition and belief lead to changes in coping behaviour [19]. CBT guides patients to think about their unreasonable cognitive and behavioural problems actively; actively adjusts the negative emotions of patients through emotional intervention; changes the views and attitudes of patients regarding disease and postoperative rehabilitation; and helps patients develop a positive thinking mode to enable them to cooperate actively with postoperative CR-I and strengthen self-management. Bethge *et al*. [20] pointed out that CR and CBT can considerably improve the health behaviours of patients undergoing cardiac surgery and help them perform exercise well. In this study, the active cooperation of the observation group with comprehensive breathing and staged exercise training gradually restored limb joint function, enhanced exercise endurance and muscle strength and further improved postoperative storage and blood flow. This situation was conducive to cardiac function rehabilitation, with a certain long-term effect.

CR-I and CBT Remarkably Improve the Exercise Capacity of Patients after AVR

This study observed the proportion of patients in the two groups who were autonomously active in bed within 3–4 days after surgery, autonomously out of bed within 8–10 days after surgery and autonomously walking for 200 m within 12–15 days after surgery. The results showed that the proportion of patients in the observation group who could complete the corresponding autonomous activities at each time point was significantly higher than that in the reference group ($p < 0.001$). This difference was related to the improvement in the independent exercise capacity of the observation group. CR-I intervention was based on the patients' staged exercise training, which was mainly used for limb function exercise within 1–3 days after surgery. In the later stage, on the basis of restoring limb joint function, endurance training with a focus on walking was gradually increased and a warm-up exercise was added before and after training to increase the patients' exercise tolerance gradually and reduce heart load. Keessen *et al*. [21] found that some patients fear exercise after surgery, thus affecting their postoperative recovery. This study also implemented CBT on patients. CBT can counteract the withdrawal behaviour that arises from negative emotions, eliminate worries and negative emotions, promote the active implementation of CR-I intervention and enable patients return to normal life quickly.

CR-I and CBT Overtly Improve the Mental Health of Patients after AVR

Wegermann *et al*. [22] revealed that anxiety often occurs after AVR. Such anxiety may be related to postoperative body discomfort or postoperative complications. Anxiety usually causes patients to lose their confidence and courage to resist their disease, resulting in poor compliance with postoperative rehabilitation training and affecting postoperative rehabilitation. CR-I has little content on mental health, instead focusing on exercise, whereas CBT is a psychological intervention therapy. Han *et al*. [23] showed

that the incidence of postoperative adverse emotions in the combined management of CBT and CR-I was considerably lower than that in the control group. In this study, the STAI score in the observation group was also significantly lower than that in the reference group ($p < 0.001$). This difference was related to the fact that CBT focuses on the mental health of patients. Medical staff usually adopt CBT to communicate with patients through questions, interviews and other methods to help them identify unreasonable thinking and behaviours; to explain the pathogenesis, risk factors, treatment points and postoperative intervention plans for aortic valve diseases; and to emphasise the importance of postoperative intervention for disease rehabilitation. Such an approach can enable patients to view themselves and their environment rationally; alleviate their negative emotions and improve their mental health.

Conclusion

CR-I combined with CBT has a certain clinical application value in patients after AVR. It can effectively improve cardiac function, enhance independent exercise capacity, reduce anxiety symptoms and improve mental health levels. However, this study is limited by its small sample size and short cycle. Therefore, in follow-up studies, further increasing the sample size and prolonging the observation time are necessary to provide an additional reference for the formulation and selection of clinical management plans for patients after AVR.

Availability of Data and Materials

Data to support the findings of this study are available on reasonable request from the corresponding author.

Author Contributions

ZB and MW performed the research. YJ provided assistance in conceptual and experimental design. ZB and YJ provided help and advice on the experiments. MW contributed to the analysis and interpretation of the data. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study has been approved by the ethical committee of Jiaozhou Central Hospital of Qingdao (approval No.: 20191103). As a retrospective study, it is not necessary to obtain informed consent of patients.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Zhou M, Zhao G, Zeng Y, Zhu J, Cheng F, Liang W. Ageing and Cardiovascular Disease: Current Status and Challenges. Reviews in Cardiovascular Medicine. 2022; 23: 135. (In Chinese)

[2] Balata M, Gbreel MI, Elrashedy AA, Westenfeld R, Pfister R, Zimmer S, *et al*. Clinical effects of cognitive behavioral therapy in heart failure patients: a meta-analysis of randomized controlled trials. BMC Complementary Medicine and Therapies. 2023; 23: 280.

[3] Blokzijl F, Houterman S, van Straten BHM, Daeter E, Brandon Bravo Bruinsma GJ, Dieperink W, *et al*. The impact of surgical aortic valve replacement on quality of life-a multicenter study. The Journal of Thoracic and Cardiovascular Surgery. 2021; 161: 1204–1210.e7.

[4] Writing Committee Members, Otto CM, Nishimura RA, Bonow RO, Carabello BA, Erwin JP, 3rd, *et al*. 2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Journal of the American College of Cardiology. 2021; 77: e25–e197.

[5] Sukul D, Albright J, Thompson MP, Villablanca P, Keteyian SJ, Yaser J, *et al*. Predictors and Variation in CR Participation After Transcatheter Aortic Valve Replacement. JACC: Advances. 2023; 2: 100581.

[6] Lourens EC, Baker RA, Krieg BM. Quality of life following cardiac rehabilitation in cardiac surgery patients. Journal of Cardiothoracic Surgery. 2022; 17: 137.

[7] Ambrosetti M, Abreu A, Corrà U, Davos CH, Hansen D, Frederix I, *et al*. Secondary prevention through comprehensive cardiovascular rehabilitation: From knowledge to implementation. 2020 update. A position paper from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology. European Journal of Preventive Cardiology. 2021; 28: 460–495.

[8] D'Andrea A, Sperlongano S, Pacileo M, Venturini E, Iannuzzo G, Gentile M, *et al*. New Ultrasound Technologies for Ischemic

Heart Disease Assessment and Monitoring in Cardiac Rehabilitation. Journal of Clinical Medicine. 2020; 9: 3131.

[9] Matsumoto K, Hamatani S, Shimizu E. Effectiveness of Videoconference-Delivered Cognitive Behavioral Therapy for Adults With Psychiatric Disorders: Systematic and Meta-Analytic Review. Journal of Medical Internet Research. 2021; 23: e31293.

[10] Li YN, Buys N, Ferguson S, Li ZJ, Sun J. Effectiveness of cognitive behavioral therapy-based interventions on health outcomes in patients with coronary heart disease: A meta-analysis. World Journal of Psychiatry. 2021; 11: 1147–1166.

[11] ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. American Journal of Respiratory and Critical Care Medicine. 2002; 166: 111–117.

[12] Gaudry E, Vagg P, Spielberger CD. Validation of the State-Trait Distinction in Anxiety Research. Multivariate Behavioral Research. 1975; 10: 331–341.

[13] Xue W, Xinlan Z, Xiaoyan Z. Effectiveness of early cardiac rehabilitation in patients with heart valve surgery: a randomized, controlled trial. The Journal of International Medical Research. 2022; 50: 3000605211044320.

[14] Sibilitz KL, Tang LH, Berg SK, Thygesen LC, Risom SS, Rasmussen TB, *et al*. Long-term effects of cardiac rehabilitation after heart valve surgery - results from the randomised CopenHeart$_{VR}$ trial. Scandinavian Cardiovascular Journal: SCJ. 2022; 56: 247–255.

[15] Archana J T, Ankita S, Gopichandran L, Devagourou V, Milind PH, Gauri SK. A descriptive exploratory study to assess the anxiety, fatigue and sleep quality of patients undergoing valvular heart surgery at tertiary care hospital. Journal of Perioperative & Critical Intensive Care Nursing. 2020.

[16] Khodaveisi M, Fallah S V, Amini R, Tapak L. Effect of Education Based on the Health Belief Model on Treatment Adherence in Patients With Heart Valve Replacement Surgery. Journal of Education and Community Health. 2023; 10: 35–42.

[17] Butz M, Gerriets T, Sammer G, El-Shazly J, Tschernatsch M, Schramm P, *et al*. The impact of postoperative cognitive training on health-related quality of life and cognitive failures in daily living after heart valve surgery: A randomized clinical trial. Brain and Behavior. 2023; 13: e2915.

[18] Helmark C, Harrison A, Pedersen SS, Doherty P. Systematic screening for anxiety and depression in cardiac rehabilitation - are we there yet? International Journal of Cardiology. 2022; 352: 65–71.

[19] Edwards KS, Chow EKH, Dao C, Hossepian D, Johnson AG, Desai M, *et al*. Impact of cognitive behavioral therapy on depression symptoms after transcatheter aortic valve replacement: A randomized controlled trial. International Journal of Cardiology. 2020; 321: 61–68.

[20] Bethge M, Thome-Soós F, Rašo LM, Weier L, Benninghoven D. Cognitive-behavioral rehabilitation in patients with cardiovascular diseases: a randomized controlled trial (CBR-CARDIO, DRKS00029295). BMC Cardiovascular Disorders. 2023; 23: 252.

[21] Keessen P, den Uijl I, Visser B, van den Berg-Emons H, Latour CHM, Sunamura M, *et al*. Fear of movement in patients attending cardiac rehabilitation: A validation study. Journal of Rehabilitation Medicine. 2020; 52: jrm00021.

[22] Wegermann ZK, Mack MJ, Arnold SV, Thompson CA, Ryan M, Gunnarsson C, *et al*. Anxiety and Depression Following Aortic Valve Replacement. Journal of the American Heart Association. 2022; 11: e024377.

[23] Han HH, Mao MY, Feng X, Yang MX. The effect of cognitive behavioral therapy combined with CR nursing on postoperative STAMI patients after PCI. Chinese Journal of Rehabilitation Medicine. 2023; 32: 302–305. (In Chinese)