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Original Article

Effect of a mobile APP-based self-care diary combined with nursing for the management of post-heart transplantation diabetes

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Abstract: Objectives: To retrospectively investigate the effect of a mobile app-based self-care diary, a nursing management method, on post-heart transplantation diabetes. Methods: A retrospective analysis was conducted on the general data of 87 patients who underwent heart transplantation in the Cardiac and Thoracic Vascular Surgery Department of Nanjing First Hospital between January 2018 and December 2023. Based on the nursing method, the patients were divided into a control group that received routine nursing measures (n=47 cases) and an observation group that implemented a mobile APP-based self-care diary combined with nursing (n=40 cases). Blood glucose indicators and generic quality of life inventory-74 (GQOLI-74) scores were compared between the two groups three months post-surgery. Results: Three months after hospital discharge, the observation group showed significantly higher values in the largest amplitude of glycemic excursions (LAGE) and the variation coefficient of fasting plasma glucose (CV-FPG) as well as the general quality of life inventory (GQOLI-74) score compared to the control group (all $P<0.01$). Conclusions: Using a mobile APP-based self-care diary in combination with nursing methods can effectively stabilize blood glucose levels and improve the life quality in post-heart transplantation diabetic patients, demonstrating significant clinical value.

Keywords: Self-care diary, mobile apps, heart transplantation, diabetes, glucose variability

Introduction

Post-heart transplantation diabetes (PHTD) mainly refers to the development of abnormal glucose tolerance, elevated fasting glucose levels, or diabetes after heart transplantation, despite the absence of preoperative glycemic abnormalities [1, 2]. The main associated mechanisms of PHTC include traumatic stress of transplantation, use of glucocorticoids, perioperative factors, and the long-term use of immunosuppressive drugs (injectable basiliximab, tacrolimus, etc.). According to relevant studies, the incidence of new-onset diabetes mellitus after heart transplantation exceeds 30%. PHTD poses significant risks by increasing the likelihood of perioperative incision infection and exacerbating drug rejection, which, along with denervation, leads to increased cardiac workload after heart transplantation and calcifies the coronary artery, eventually affecting transplant survival [3, 4]. Both domestic and foreign scholars have proposed the concept of a self-care diary after organ transplantation, which has been applied in clinical practice and achieved good results [5, 6]. This self-care diary focuses on the importance of post-operative immunosuppressive treatment and regular follow-ups, primarily aiming to prevent organ rejection. It encourages patients to actively participate in self-management after the surgery, including maintaining a balanced diet, avoiding high-salt and high-fat foods, and controlling blood sugar, adhering to a regular routine, and engaging in moderate exercise to promote recovery and adaptation of the new organ [7]. Therefore, this study analyzed the effectiveness of a mobile APP-based self-care diary combined with nursing management in the context of PHTD, hoping to diversify the research directions for improving the intervention effect on PHTD.

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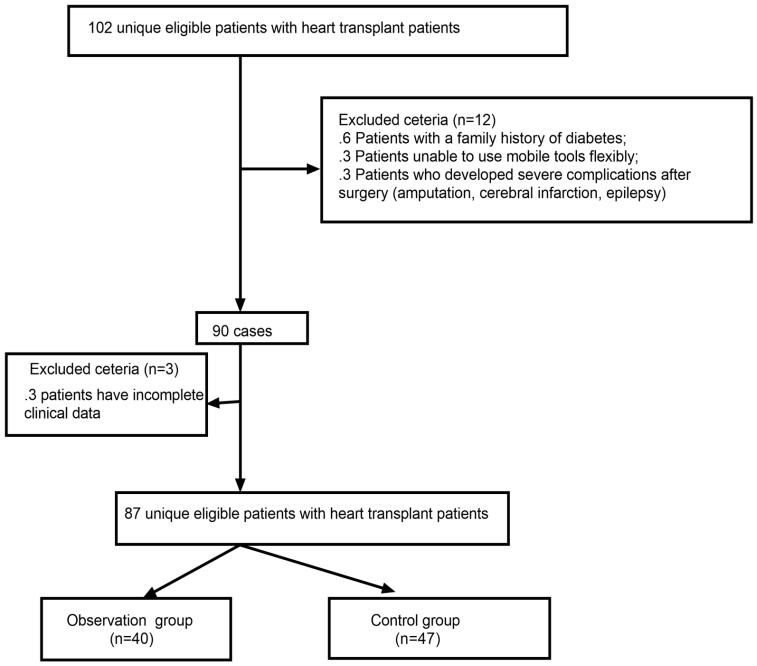

Figure 1. Flowchart of patient selection.

General information and methodology

General information

A retrospective analysis was conducted on the general data of 87 patients who underwent heart transplantation in the Cardiac and Thoracic Vascular Surgery Department of Nanjing First Hospital between January 2018 and December 2023. Based on the nursing methods, the patients were divided into a control group that received routine nursing (n=47) and an observation group that used a mobile APP-based self-care diary combined with nursing management (n=40). This research was approved by the Ethics Committee of Nanjing First Hospital (KY20240902-KS-04). The study flowchart is shown in **Figure 1**.

Inclusion criteria: 1. Patients aged 18 and above; 2. Patients who completed the entire treatment cycle in our hospital; 3. Patients without diabetes mellitus before heart transplantation; 4. Patients who developed postoperative diabetes meeting the 2018 American diabetes diagnosis and treatment standards after heart transplantation [8].

Exclusion criteria: 1. Patients with a family history of diabetes mellitus; 2. Patients who were unable to use mobility tools effectively; 3. Patients who developed serious complications (e.g., amputation, cerebral infarction, epilepsy) after heart transplantation.

Methodology

At our heart center, we have consistently maintained strict blood glucose control for heart transplant patients, including routine records of blood glucose levels seven times a day. Additionally, we regularly documented patients' quality of life both before and after surgery. During hospitalization, PHTD was primarily managed according to the expert consensus on perioperative glucose management. Once patients' conditions stabilize, on-duty doctors implemented dietary control and glucose management, and specialists from the Endocrinology Department and the Rehabilitation Department collaborated to provide precise glucose management and rehabilitation treatment for the patients [9].

Nursing management in the control group

The control group received standard hospital care, which includes monitoring the patient's clinical symptoms, signs of infection, changes in vital signs, and responses to medications. Routine care also involves blood pressure management, dietary guidance, personal hygiene instructions, and medication assistance. Family members were instructed to closely monitor and record the patient's blood glucose levels and cooperate with the nursing staff [10].

Nursing management in the observation group

A multi-specialty heart transplantation blood glucose management team was established, comprising an attending cardiac surgeon, an associate chief physician of endocrinology, a cardiac rehabilitator, a pharmacist, and two cardiology specialist nurses. The Endocrinology Department provided blood glucose guidance in the follow-up period; the pharmacist and the cardiology specialist nurses were

responsible for managing insulin dosage; the cardiac rehabilitator designed and guided rehabilitation programs; the cardiac surgeon was responsible for cardiac re-check and cardiac function maintenance; the cardiology specialist nurses monitored patients' psychological conditions, implemented appropriate nursing measures, and collected diary data as well as the life quality scores and coordinated with specialists for advice via our official WeChat account [11].

Intervention via diet diary: The multi-specialty team developed a diabetes diary template, which included sections for preoperative diagnosis, surgery date, gender, standard body mass, daily energy requirements, and detailed records of food intake. The diary tracked the types and amounts of food consumed during the three main meals or non-meal times, and included diabetes-related treatment information, such as oral medications, insulin dosage, and blood glucose levels before and after meals. Before hospital discharge, patients and their family members received guidance from specialist nurses on calorie counting, food composition analysis, and the food exchange method, ensuring they could accurately calculate daily energy intake. Endocrinology nurses also instructed patients on the proper use and storage of insulin. Patients were required to upload their completed diet diaries to the WeChat platform daily. Nurses reviewed the diaries for accuracy, communicated with patients to correct any errors, and submitted the finalized records to the multi-specialty team. Based on these records, the endocrinology team provided personalized medication and diet guidance, which was delivered to the patients via WeChat. Specialist nurses confirmed the information and offered additional guidance through WeChat and phone calls.

Intervention via rehabilitation training: The cardiac rehabilitation physician was responsible for designing the rehabilitation training recording form and related instructions. After patients had their monitoring instruments and drains removed and were cleared for rehabilitation by the cardiac surgeon, the rehabilitation physician prescribed training routines for both the hospitalization and post-discharge periods. During hospitalization, patients performed functional exercises such as muscle relaxation, breathing exercises, and joint mobility exercises for the shoulders, hips, knees, and ankles, along with squatting and walking exercises based on their condition. After hospital discharge, patients were prescribed resistance exercises [12], including upper and lower extremity resistance training (e.g., chest compressions, knee extensions and flexions, biceps curls, triceps extensions, pull-downs, shoulder presses, and abdominal exercises) at least twice a week. Each exercise was repeated 10 to 15 times. Additionally, patients were advised to perform low-intensity walking as a warm-up before each session. The key to effective cardiac rehabilitation is appropriate exercise intensity. Based on relevant research [13], the team set a target heart rate of 70%-85% of the patient's maximum heart rate and used Borg's Rating of Perceived Exertion (RPE) scale to gauge exercise intensity. Given that heart transplant patients lose sympathetic innervation to the heart, their heart rate does not increase significantly during exercise. Therefore, the target heart rate served as a guideline to ensure safe exertion. At the end of each day's exercise, patients uploaded their recorded values to the WeChat platform, where nurses reviewed the data and submitted it to the multidisciplinary team. Based on this information, the cardiac surgeon and rehabilitation physician collaboratively adjusted the patient's exercise intensity, increasing or decreasing it as needed.

Intervention via psychological training: In this study, the psychological conditions of heart transplant patients were assessed using the SCL-90 scale (Symptom Checklist-90) and the SSRS (Social Support Rating Scale), as outlined by Yang Yanfang and other scholars [14]. The SCL-90 scale evaluates nine primary psychological symptoms: somatization, obsessive-compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism. Each symptom is rated on a 5-point scale from 0 (indicating better psychological conditions) to 4 (indicating poorer psychological conditions). The SSRS assesses social support across three dimensions (objective support, subjective support, and social availability) with a total of 10 items. Higher scores on the SSRS indicate a greater level of social support. The psychological intervention was divided into two phases.

During hospitalization, cardiac specialist nurses administered the SCL-90 and SSRS scales daily, guiding patients on how to complete them. Interventions were then provided based on previous studies and patient needs. These interventions included educational materials (texts and images) about heart transplantation methods, preoperative preparation, and the inspiring story of a model patient who survived for 21 years after undergoing a heart transplant at our hospital. This model patient regularly visited to share his experiences with other patients. After the patients returned to the general wards post-surgery, our hospital provided VIP transplant wards equipped with a quiet environment, convenient living facilities (refrigerator, microwave oven, private bathroom, and comfortable beds), and played light music daily (from 09:00-10:00 a.m. after treatment). Additionally, our hospital partnered with social charities to provide financial assistance to cardiac patients. This included fee waivers and reductions for those from low-income families, ensuring maximum support. Psychological interventions were tailored based on patients' scale scores. After discharge, the primary factor influencing patients' psychological status was social support, derived from family and social networks. The SSRS was used to evaluate support factors, such as community welfare assistance, family communication to maintain harmony, and support from colleagues and supervisors upon return to work. The patients' SCL-90 and SSRS scores were continuously monitored, and psychologists were involved if necessary to address mental health concerns. The psychological status of heart transplant patients was comprehensively assessed using depression and anxiety scales, ensuring timely interventions to address any emerging issues.

Primary outcome

Indicators related to blood glucose control effectiveness were calculated by endocrinologists, including changes in LAGE (largest amplitude of glycemic excursions) and CV-FPG (coefficient of variation of fasting plasma glucose) levels. LAGE is defined as the difference between maximum and minimum daily blood glucose values, and CV-FPG is calculated as: (Blood glucose standard deviation/Average blood sugar) ×100%.

Secondary outcome

Generic quality of life inventory-74 (GQOLI-74) was used to assess the quality of life of patients in both groups three months after discharge. The GQOLI-74 involves four dimensions: material life, physical health, psychological health, and social functioning. This scale comprises 74 items, each scored on a 1 to 5 scale, with a maximum score of 100 points. Higher scores indicate better quality of life.

Data statistics

Data were analyzed using SPSS 20.0 statistical software. The measurement data were expressed as mean ± standard deviation (Mean ± SD) and compared between the two groups using an independent t-test. Enumeration data were expressed as numbers and percentage and compared between the two groups using the chi-square test. A $P<0.05$ was considered statistically significant.

Results

Survival of patients

Among the 87 patients in this group, no deaths were observed during the data collection period.

Comparison of baseline data between the two groups

According to the comparison results, the two groups of patients showed no significant differences in age, gender, marital status, education, primary diseases and other general information (all $P>0.05$), indicating that the two groups were comparable, as shown in **Table 1**.

Comparison of intraoperative data between the two groups

The intraoperative data, including extracorporeal circulation time, aortic block time, and total cardiac arrest fluid volume, showed no significant differences between the two groups (all $P>0.05$), as shown in **Table 2**.

Comparison of postoperative data between the two groups

According to the results, the two groups showed no significant differences in terms of postoperative awake time, mechanically assisted ventilation time, ICU stay duration, total hospital-

Table 1. Comparison of general information between the two groups

Category	Observation group (n=40)	Control group (n=47)	Statistical value	*P* value
Age (Year)	55.8±9.7	55.3±10.1	0.345	0.731
Gender (Male/Female)	22/18	27/20	0.033	0.811
Marital status			0.510	0.775
Married	37	44		
Single	1	2		
Divorced	1	1		
Education			0.744	0.388
Below high school	11	17		
High school or above	29	30		
Residential zone			0.058	0.810
Rural	12	13		
Urban	28	34		
Primary disease			0.442	0.705
End-stage coronary heart disease	4	8		
Dilated cardiomyopathy	26	31		
Heart failure after valve surgery	10	8		
Others	6	7		
Number of hospitalizations before transplantation	3.2±0.8	3.1±0.9	0.804	0.442
Waiting time for transplant (months)	9.7±1.2	9.9±1.6	0.974	0.331
Fasting blood glucose before transplantation (mmol/L)	4.6±0.4	4.7±0.3	1.911	0.058
Body mass index (kg/m^2)	24.6±4.9	25.0±5.1	0.546	0.585

Table 2. Comparison of intraoperative data between the two groups

Observation Indexes	Observation group	Control group	T value	*P* value
Extracorporeal circulation time (min)	189.5±7.6	190.2±8.2	0.514	0.607
Perfusion time (s)	98.4±7.8	97.5±8.4	0.627	0.557
Aortic block time (min)	162.1±3.3	160.8±2.5	0.658	0.694

Table 3. Comparison of postoperative data between the two groups

Observation Indexes	Observation group	Control group	t value	*P* value
Postoperative awake time (h)	10.2±0.6	10.8±0.5	0.659	0.261
Mechanically assisted ventilation time (s)	14.2±2.1	13.9±2.0	0.803	0.431
ICU stay time (d)	1.2±0.4	1.1±0.3	1.575	0.118
Hospitalization time (d)	18.7±5.5	19.0±5.4	0.381	0.781
Stroke	0	1	-	-
Acute renal insufficiency	2	1	0	1.000

ization time, or the incidence of stoke and acute renal insufficiency (all P>0.05), as shown in **Table 3**.

Comparison of LAGE and CV-FPG between the two groups

The study found that blood glucose indexes including LAGE and CV-FPG of the observation group were significantly lower than those in the control group (all P<0.05), as shown in **Table 4** and **Figure 2**.

Comparison of the GQOLI-74 score between the two groups

The GQOLI-74 scores across four dimensions in the observation group were all significantly

Table 4. Comparison of blood glucose-related indexes between the two groups of patients

Category	Observation group	Control group	t value	*P* value
LAGE (mmol/L)	4.63±1.20	5.78±1.29	6.312	0.001
CV-FPG (%)	12.16±2.78	15.67±3.45	7.699	0.001

Notes: LAGE: The largest amplitude of glycemic excursions; CV-FPG: The variation coefficient of fasting plasma glucose.

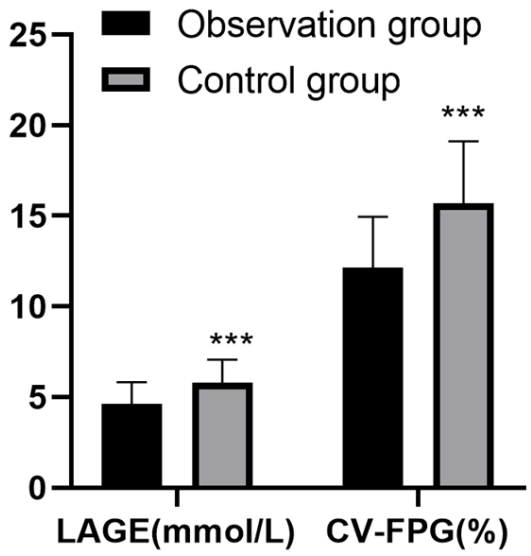

Figure 2. Comparison of LAGE and CV-FPG levels between the two groups. Notes: LAGE: The largest amplitude of glycemic excursions; CV-FPG: The variation coefficient of fasting plasma glucose. ***, P<0.001.

higher than those of the control group (all P<0.05), as shown in **Table 5**.

Discussion

Heart transplantation remains the primary treatment for end-stage heart disease. With the advances in perioperative anesthesia technology and the efficacy of anti-immune drugs, heart transplantation has become increasingly common, with a survival rate of higher than 90% [15, 16]. However, enhancing the long-term survival of heart transplant patients remains a crucial area of research. Besides acute and chronic organ rejection, post-heart transplantation diabetes (PHTD) is another significant factor influencing long-term outcomes. Key risk factors for PHTD include preoperative baseline data (BMI), donor-related indexes (such as blood-coagulation time), postoperative anti-immune therapy, and other non-intervention aspects. If PHTD is not effectively managed, it can lead to complications such as perioperative infections, extended hospital stays, and even transplant failure, which may ultimately result in patient death [17, 18]. Therefore, successful PHTD management has great significance for heart transplant patients. Effective management strategies should include careful attention to postoperative diet, psychological state, and rehabilitation training. These interventions play a vital role in optimizing glucose control and enhancing the overall quality of life for heart transplant recipients.

Diet intervention is a cornerstone in managing diabetes. Effective diet management relies heavily on patients' self-discipline and compliance. In response to these challenges, mobile glucose management apps have been developed to help patients control their blood glucose levels through features such as blood glucose monitoring, dietary and exercise tracking, and medication reminders. For example, some blood glucose management apps can directly link with blood glucose monitors, allowing real-time recording of glucose levels, which helps patients maintain a continuous awareness of their blood glucose status [19-21]. Besides, many apps have diet management functions that can record eating habits and analyze nutritional intake, enabling patients to develop scientifically sound diet plans [22]. In this research, the diet diary APP was used postoperatively to help heart transplantation patients balance their food intake with their energy needs, thereby stabilizing blood glucose levels. Using the data provided through the APP, the endocrinology specialist provided professional guidance, adjusting medications and providing advice aimed at maintaining glucose levels within the normal range. In addition, the record-feedback mode helped patients adapt to the dietary requirements, improving their compliance and, ultimately, the effectiveness of diet interventions. Postoperative rehabilitation training is another vital component of heart transplantation recovery. According to relevant studies, rehabilitation training can also assist in blood glucose control. In this study, a low-resistance training method was employed to control blood glucose elevation induced by glucocorticoste-

Table 5. Comparison of the life quality score between the two groups

Category	Observation group	Control group	t value	*P* value
Somatic functions	46.8±1.4	42.3±1.3	22.662	0.001
Psychological functions	64.7±4.5	61.8±5.8	3.844	0.001
Material life functions	49.6±3.9	42.7±5.9	9.543	0.001
Social functions	67.9±3.4	63.0±4.2	8.812	0.001

roids and steroids, while also preventing muscle damage caused by these medications. This intervention supported previous findings that rehabilitation training strengthens glucose control [23, 24]. Furthermore, psychological factors such as anxiety and depression can negatively impact blood glucose management. This study incorporated regular assessments of psychological well-being and implemented active interventions to improve the mental health of heart transplant patients. Social support networks were also strengthened to aid in maintaining a healthy diet and rehabilitation regimen. This comprehensive approach to improving psychological conditions contributed to better glucose control, aligning with findings from other studies [25].

The self-care diary, a tool for recording and reflecting on daily physical and psychological conditions, has gained recognition for its benefits. A self-care diary is not just a notebook for recording daily life details such as diet, sleep, and exercise, but as a mechanism for introspection and self-reflection [26, 27]. By recording our daily activities, patients gain insights into their lifestyles and can identify both beneficial and detrimental habits. This approach has proven effective for diabetic patients, offering them a simple yet powerful means for managing their health [28]. In addition, the self-care diary can strengthen patients' self-monitoring and self-management capabilities, deepening their knowledge and understanding of the disease, promoting active participation in their own care. The quality of life is a crucial index reflecting the effectiveness of treatment activities. The results in this study showed that the self-care diary-combined-mobile APP nursing method can effectively control blood glucose through dietary adjustments, improve cardiopulmonary function through tailored rehabilitation training, and reduce potential muscle damage or atrophy potentially caused by anti-rejection drugs. This comprehensive approach ensures that patients receive adequate post-surgery training while also addressing their psychological well-being. Continuous monitoring of psychological conditions allows for timely interventions, helping patients better integrate into society and engage in social and work activities [29]. Moreover, this study indicates that the mobile APP-based self-care diary in combination with nursing significantly enhances various dimensions of quality of life, including somatic functions, psychological well-being, material life, and social functioning. These improvements underscore the effectiveness of this integrated approach in elevating the overall quality of life for patients after heart transplantation [30].

In conclusion, PHTD is a significant factor affecting the long-term survival of patients after heart transplantation, highlighting the need for effective management strategies for PHTD in clinical practice. The mobile APP-based self-care diary in combination with nursing method has demonstrated its potential to enhance blood glucose management by incorporating psychological, dietary, and rehabilitative interventions. Despite these promising results, this study is limited by its single-center, small-sample, and minimal comprehensiveness. Future multi-center and large-sample research should be conducted to better solidify the findings of this study.

Disclosure of conflict of interest

None.

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