

Research letter

Active Remote Monitoring of Cardiac Surgical Patients Using Digital Telemedicine Technologies Improves Patient Adherence in The Distant Period

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Abstract: *Objective* — to study the dynamics of data on adherence to treatment according to the Morisky-Green questionnaire in patients participating in an active remote monitoring program, before and after participation in the program.

Material and methods — Fifty patients, mean age 60 ± 12 years, were initially enrolled in the remote monitoring programme. The median follow-up in the study was 29 months (28; 31). Twelve months after the end of the study, we administered a questionnaire to patients ($n=42$) who were followed up until the end of the programme. We used the same questionnaires as at baseline (SF-36, Morisky-Green, HADS and UCLA (University of California, Los Angeles) questionnaire) to determine the dynamics of their parameters.

Results — On the Morisky-Green questionnaire, scores increased from 2 (2; 3) to 4 (3; 4) points, $p < 0.001$. Statistically significant differences in dynamics were also revealed for the other questionnaires (except for the SF scale of the SF-36 general health questionnaire). The dynamics in all cases was positive: the quality of life increased compared to the initial value, the level of anxiety and depression decreased, the level of loneliness expression decreased.

Conclusions — Patient participation in an active remote monitoring program had significant long-term value in improving treatment adherence. Patient adherence improved from baseline on the Morisky-Green questionnaire: one year after program termination, the level of adherence in this cohort of patients was close to the maximum.

Keywords: adherence to treatment, remote monitoring, smart devices, telemedicine, remote health monitoring, cardiac surgery, cardiovascular diseases.

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Introduction

High patient adherence to treatment regimens is crucial for successful postoperative recovery and long-term prognosis, especially following surgical procedures [1, 2]. The global scientific literature describes a multitude of strategies to enhance adherence. These encompass patient education and training programs, simplification of medication schedules, active support and reminders from healthcare providers, as well as fostering empathy and trust in the physician [3-5].

Another approach to actively monitor patient status and improve adherence involves the use of smart devices for remote collection of specific health parameters. Modern digital devices, such as personal electrocardiogram (ECG) and blood pressure (BP) monitors, along with wearable fitness trackers, can assist both patients and physicians in tracking treatment progress and motivating compliance with recommendations [6, 7].

Our previous pilot study evaluated the feasibility of patients using personal medical devices at home. We identified patients with various cardiac arrhythmias as a target group for personal ECG monitors, who exhibited high adherence to device use [8]. Furthermore, achieving target BP levels in the study was not associated with an increased risk of patient dropout [9].

Participation in such active surveillance programs may potentially influence patients' long-term treatment adherence even after the program concludes and direct physician oversight is discontinued. This led us to investigate whether an educational effect occurs, enhancing motivation for regular self-monitoring over time based on the patient's experience with intensive clinical supervision.

The aim of this analysis was to assess the dynamics of adherence screening data at baseline (prior to study inclusion) and in the long term – one year after the monitoring program ended.

Material and Methods

Remote Patient Monitoring Program. A more detailed description of this program can be found in previously published articles [8-11]. The system operated as follows: after discharge from the clinic, patients continued their medical follow-up at home using three types of portable personal digital devices—a personal electrocardiograph for recording a single-channel ECG, an automated tonometer (blood pressure monitor), and a fitness tracker to monitor physical activity. Each of these devices connected to a dedicated mobile application (available for both iPhone and Android), which automatically transmitted all collected

metrics to a secure server. Physicians could review this data in real-time via a personal account on a specialized web portal.

In addition to the collection of objective parameters, a comprehensive assessment of patient status was conducted using several standardized instruments: the SF-36 questionnaire to analyze quality of life, the Morisky-Green Scale to assess treatment adherence, the Hospital Anxiety and Depression Scale (HADS) to identify anxiety and depressive states, and the UCLA Loneliness Scale (University of California, Los Angeles) to evaluate the level of loneliness.

The study initially enrolled 50 patients with a mean age of 60±12 years. All patients included in the study underwent examination or surgical treatment in a single department of our institution. The median follow-up duration in the study was 29 months (IQR 28; 31). During the first 12 months, 8 patients discontinued follow-up. The remaining patients (n=42) were observed for the entire study duration. Their clinical characteristics are presented in [Table 1](#).

Table 1. Clinical characteristics of the enrolled patients

Parameter	Value (n=42)
Age, years	60±12
Male, %	54
Coronary Artery Disease (CAD), %	50
Angina Pectoris, %	43
Previous Myocardial Infarction (MI), %	14
Diabetes Mellitus, %	12
Chronic Obstructive Pulmonary Disease (COPD), %	9
Arterial Hypertension, %	86
Stroke/Transient Ischemic Attack (TIA), %	7
Smoking, %	19
Surgical Treatment for CAD, %	41
- Coronary Artery Bypass Grafting (CABG), %	17
- Percutaneous Coronary Intervention (PCI), %	24
Surgical Treatment for CHD/AVD, %	24
Surgical Treatment for Cardiac Arrhythmias, %	38
- Radiofrequency Ablation (RFA), %	26
- Pacemaker (PM) Implantation, %	12

CAD, Coronary artery disease; MI, Myocardial infarction; COPD, Chronic obstructive pulmonary disease; TIA, Transient ischemic attack; CABG, Coronary artery bypass grafting; PCI, Percutaneous coronary intervention; CHD, Congenital heart disease; AVD, Acquired valvular disease; RFA, Radiofrequency ablation; PM, Pacemaker.

Table 2. Comparison of Questionnaire Data

Parameter	Baseline (n=42)	Long-term (n=42)	p-value
HADS – A (Anxiety)	7 (3; 9)	5 (3; 6)	<0.001
HADS – D (Depression)	4 (2; 8)	4 (2; 7)	0.018
SF-36 Scale			
PF – Physical Functioning	70 (60; 85)	70 (65; 85)	0.008
RP – Role-Physical	25 (0; 50)	50 (25; 50)	0.003
BP – Bodily Pain	72 (51; 84)	74 (51; 90)	0.012
GH – General Health	52 (40; 72)	55 (45; 75)	0.027
VT – Vitality	60 (45; 70)	60 (55; 75)	0.002
SF – Social Functioning	75 (63; 88)	76 (65; 88)	0.057
RE – Role-Emotional	33 (33; 100)	67 (67; 100)	<0.001
Physical Component Summary (PCS)	43 (37; 47)	47 (41; 51)	0.025
Mental Component Summary (MCS)	50 (42; 55)	53.4 (45; 59)	<0.001
UCLA Loneliness Scale	32 (29; 39)	39 (35; 52)	<0.001
Morisky-Green Test	2 (2; 3)	4 (3; 4)	<0.001

Data are presented as median (interquartile range). HADS, Hospital Anxiety and Depression Scale; SF-36, Short Form Health Survey.

Following the completion of the monitoring program, patients were subsequently managed by their local cardiologists. Twelve months after the study's conclusion, we conducted a follow-up survey of the patients (n=42) who had completed the entire program. We administered the same set of questionnaires used at baseline to assess the dynamics of their parameters.

Patients who dropped out of the study (n=8) were not specifically targeted for this follow-up survey, as they did not participate in the full program and, consequently, were not exposed to the educational component of the intervention.

Statistical analysis

Statistical analysis was performed using the STATISTICA® 12.0. «Statsoft» (USA). Quantitative parameters are presented as median (Me) and interquartile range (Q1; Q3), since the data distribution did not follow the normal distribution law (assessed by the Shapiro-Wilk test). Categorical parameters are presented as absolute numbers (n) and proportion within the studied cohort (%). The Wilcoxon test was used to compare two dependent samples for quantitative variables. The difference between groups was considered statistically significant at p<0.05.

Results

[Table 2](#) presents the dynamics of the questionnaire data at baseline (initial screening, prior to study enrollment) and at the long-term follow-up (12 months after the program's completion).

The primary result of this study was a statistically significant increase in treatment adherence levels compared to baseline. According to the Morisky-Green test, scores increased from 2 (2;3) to 4 (3;4), p<0.001. This indicates that one year after the cessation of the active monitoring program, the level of adherence in this patient cohort was close to the maximum. It is important to note that significant dynamic changes were also observed in other questionnaires (except for the SF scale of the SF-36). As expected, the trend was positive in all cases: quality of life improved from baseline, anxiety and depression levels decreased, and the severity of loneliness on the UCLA scale also decreased.

Discussion

The obtained results can be explained from several perspectives. Firstly, since the majority of these patients underwent surgical interventions aimed at correcting specific conditions, it is logical that their overall health status would improve over time, which is precisely what occurred. This is objectively confirmed by the significant positive dynamics in the general SF-36 health survey. Secondly, immediately after surgery, these patients were enrolled in a remote monitoring program and for over two years (median follow-up of 29 months) were in a regime of daily measurement of cardiovascular parameters with physician oversight. This influenced the patients' psychological and motivational status. We observe that not only did treatment adherence (motivation) improve, but the severity of loneliness, anxiety, and depression also decreased. Furthermore, this effect persisted for at least 12 months after the program ended.

Support from medical staff, in the form of regular active monitoring including scheduled consultations and proactive patient status checks (physician-initiated consultations), helps maintain motivation. This also includes various types of reminders: phone calls, SMS messages, or electronic reminders for medication

intake or doctor appointments, as well as various technological solutions. For example, mobile applications for tracking medication adherence, physical activity, or other health parameters. Smart devices, such as personal ECG and BP monitors, and wearable gadgets (e.g., fitness trackers) can help patients track their progress and motivate them to follow recommendations.

Establishing a warm physician-patient relationship, demonstrating care and understanding of the patient's problems, is the most challenging yet most effective method for improving compliance with required recommendations. This also includes involving family and close ones. Relatives and friends can assist the patient in following recommendations by providing emotional support and supervision. Additionally, participation in patient support groups with similar problems can enhance motivation through experience sharing and mutual support.

Similar studies demonstrate impressive and encouraging results: patients using remote monitoring systems after heart surgery showed better adherence to rehabilitation programs and fewer rehospitalizations [12-16]. Ambulatory remote monitoring is particularly effective for chronic conditions such as diabetes mellitus, hypertension, and chronic obstructive pulmonary disease. The use of mobile apps for glucose monitoring in diabetic patients was found to increase treatment adherence by 20–30%. Participation in remote monitoring led to a 15% increase in the proportion of patients correctly taking antihypertensive medications. Such participation in an "active" treatment approach fosters sustainable habits that persist even after the program concludes [17-20].

Patient participation in our active remote monitoring program indeed had long-term significance for improving treatment adherence. This approach is becoming increasingly popular due to the advancement of technologies such as mobile applications, wearable devices, and telemedicine platforms [21]. Scientific research confirms that an "active" treatment approach promotes increased adherence, improved clinical outcomes, and reduced healthcare costs.

Conclusion

Patient participation in the active remote monitoring program had significant long-term value for improving treatment adherence. The level of treatment adherence relative to baseline, as measured by the Morisky-Green test, increased: one year after the program ended, the adherence level in this patient cohort was close to the maximum.

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Ethical approval

The study was approved by the local ethics committee of the Bakulev National Medical Research Center for Cardiovascular Surgery and conducted in accordance with the principles of the Helsinki Declaration and

the standards of Good Clinical Practice. All patients provided voluntary written informed consent prior to inclusion in the study.

Conflict of Interest

The authors declare no conflicts of interest.

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