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Original paper

The role of mHealth technology in the secondary prevention of cardiovascular disease

STEFAN S BUSNATU[1], ALEXANDRU ION[1], MIHAELA RAILEANU[1], IRINA CALANGEA[1], FLORENTINA FURTUNESCU[1], CATALIN CHERA[2], RADU IANCU[2], NIRVANA POPESCU[2], STEFAN COVACI[3], ANASTASIUS GAVRAS[4], CHRISTOPH THUEMMLER[5], CRINA J SINESCU[1]

[1]Universitatea de Medicina și Farmacie Carol Davila, Bucuresti, RO
[2]Universitatea Politehnica din Bucuresti, RO
[3]Technische Universitat Berlin, DE
[4]Eurescom GmbH, Heidelberg, DE
[5]Napier University, Edinburgh, SCT

Abstract

Background: Cardiovascular diseases account for 47% of all deaths in Europe, currently constituting one of the highest public relevance disease categories. Innovations in telecommunication technologies could enable the advent of cardiac telerehabilitation.

Objectives: The purpose of the research was to assess the efficiency of a Cloud based system designed for telerehabilitation in patients that suffered a myocardial infarction.

Materials and Methods: 69 patients enrolled in a rehabilitation program, divided in two groups, 32 performed a personalised rehabilitation program using the proposed solution and 37 patients performed individual unmonitored noninstitutionalised rehabilitation, based on the discharge report recommendations provided following their hospitalisation.

Results: The cardiovascular fitness levels were improved in the group of patients that performed the online rehabilitation, with improved ejection fraction (average growth of 5%), of the estimated cardiopulmonary capacity during effort (average growth of 8%) and a decrease of the vascular stiffness (average 0.02%). From the general user and technological experience evaluation, the solution received a good acceptability score.

Conclusion: This innovative type of rehabilitation offers real-time interaction between doctor and patient, to detect dangerous situations and seems feasible for conducting a tele-rehabilitation program.

Keywords Telerehabilitation, cardiovascular diseases, ehealth

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*Corresponding author: STEFAN S BUSNATU, Universitatea de Medicina si Farmacie Carol Davila, Dionisie Lupu no 37 Street, Bucharest, RO 020021
Email: stefan.busnatu@umfcd.ro

Introduction

The European Heart Network's statistics indicate that every year cardiovascular disease(CVD) accounts for 47% of all deaths in Europe, thereby currently constituting one of the highest public relevance disease categories (WILKINS E. & al. [1].

Among patients who survive following an acute cardiac event, 20% suffer a second cardiovascular event in the first year, approximately 50% of major coronary events occur in those with a previous hospital discharge diagnosis of myocardial infarction and one year mortality rates are still in the range of 10% (PIEPOLI MF & al [2].

The European Society of Cardiology (ESC) guidelines recommend secondary prevention programs (i.e. cardiac rehabilitation – CR) after the initial event to prevent recurrent disease and improve long-term prognosis (PIEPOLI MF & al [3], PONIKOWSKI P & al [4].

Cardiac rehabilitation has been developed, as a solution for reducing the high medical costs implied by the cardiovascular diseases. It represents a multidimensional treatment plan, for men and women with cardiovascular disease, consisting of interventions at the level of nutritional habits, risk factor modification, psychosocial interventions, physical activity counselling and exercise training (ECKEL RH & al [5].

Despite the proven clinical effectiveness of conventional center-based CR programs in reducing morbidity and mortality (ANDERSON L & al [6], long-term benefits are often disappointing, mainly due to low CR uptake and compliance rates (KOTSEVA K & al [7].

This translates into a significant persistent chronic disease burden with associated escalating healthcare costs. Overall CVD is estimated to cost the EU economy €210 billion a year. Of the total cost of the cardiovascular diseases in the EU, 53% (€111 billion) are related to direct health care costs, 26% (€54billion) to productivity losses and 21% (€45 billion) to the informal care of people with cardiovascular diseases (WILKINS E. & al. [1]. The restriction of current healthcare budgets, is prompting the need for developing alternative cost-efficient care strategies.

The increased use of smartphones associated with the continuous expanding mobile broadband connectivity are changing the way health-care is accessed, monitored and delivered. It is expected that by 2020 the number of mobile broadband subscriptions will reach to 7.7 billion while the amount of smartphone subscriptions is expected to get to about 70% of the world's population [8] .

Thanks to the fact that smartphones have the capability to connect with peripheral devices, they serve as a personal digital hub integrating different monitoring equipments and health applications (apps) that collect and transmit individualized health-related data (WALSH JA & al [9], WIDMER RJ & al [10] .

Innovations in telecommunication technologies could enable the advent of cardiac telerehabilitation; comprehensive and personalized secondary prevention in which patients rehabilitate remotely using telemonitoring, telecoaching and e-learning (FREDERIX I & al [12].

In Romania, currently, standardized programs for cardiac rehabilitation are not reimbursed by the National Health Insurance House. Due to the low economic level within the general population, cardiovascular patients can`t afford to attend in such programs in institutionalized private facilities (KULCSAR I [13].

Therefore, although the benefits of recovery are well known, Romanian patients get to benefit in a very small number of such services. A lower costs alternative, that could help in the development and implementation of cardiac rehabilitation programs for areas where there are no such services, would be to develop and deploy remote cardiac rehabilitation services using eHealth.

The purpose of the present research has been to develop and asses the medical efficiency of a complex Cloud based system dedicated to patients that suffered a myocardial infarction, allowing them to perform a home based medical supervised online cardiovascular rehabilitation program.

Material and Methods

The research was conducted within the University of Medicine and Pharmacy "Carol Davila" (UMFCD) under the European project FI-STAR FP7 Project (Future Internet Social and Technological Alignment Research). The research team within UMFCD built a system based on "Cloud Computing" services, with components dedicated to patients and medical staff such as:

A. The space of interaction with users "Front-End":

- The desktop application – dedicated to the medical personnel for real-time monitoring of patients
- The mobile application – installed on the patients Smartphone, facilitated the collection of the vital signs from the attached medical devices and their transmission to the monitoring centre. (Figure 1).

Figure 1. CardioStar mobile application interface

B. Data collection and analysis system, the” Back-end” represented by the private “Cloud” installed and configured in the Cardiology Department.

The tests of the telemonitoring system were performed in two stages, during 10 months. In this period, complementary to the process of collecting health data, there were acquired information concerning the quality of experience and services provided by the system. These allowed the assessment of the technological performance indicators of the system, in addition to the medical efficiency.

The process of online cardiac rehabilitation

The research was conducted on patients that suffered a myocardial infarction, according to a well defined and structured clinical procol with approval obtained from the Ethical Comitee of the Carol Davila University of Medicine and Pharmacy.

Based on the inclusion and exclusion criterias, 69 patients diagnosed with myocardial infarction, aged up to 65 years, hospitalized in the Cardiology Department of “Carol Davila” University of Medicine and Pharmacy Bucharest within “Bagdasar Arseni” Emergency Hospital were selected after signing the informed consent.

They were divided into two groups, one of 32 patients, monitored using the proposed system and a control group of 37 patients, that performed their recovery in an uninstitutionalized manner, based on the information obtained during hospitalization.

The general rehabilitation schema of each patient involved two phases. The first phase (in the hospital 5-7 days) was common to both groups. This was initiated by early mobilization of patients, according to a medically supervised physical activity protocol. In the morning and evening patients received graphics tablets to watch educational materials, in order to learn more with regard to the secondary prevention measures.

The patients in the monitored group, after signing a handover protocol, received a set of electronic devices for monitoring vital parameters, with capabilities of transmitting data wirelessly via Bluetooth (blood pressure monitor, pulsoximeter, chest strap band) and an Android smartphone to facilitate communication with the monitoring center.

These devices allowed remote monitoring of the following parameters: Blood pressure, Oxygen saturation, Heart rate and electrocardiogram (ECG). Before discharge, all patients were evaluated through an ECG treadmill stress test which, in conjunction with the medical tests performed during hospitalization, quantified basal level of cardiovascular fitness. Based on these assessments, a personalised cardiac rehabilitation plan was developed to ensure patients safety during the physical activity sessions.

After discharge, patients have passed in phase – II of cardiac rehabilitation program, lasting 7 weeks. The group of unmonitored patients performed the ambulatory recovery program, as learned from video presentations and following recommendations from the usual hospital discharge report. The monitored patients followed a custom recovery protocol that included: a program of physical activity of 3-5 sessions per week (effective duration of 30 minutes, with a time of 10 minutes of warm up and 10 minutes of recovery), accompanied by a personalized therapeutic and nutritional plan.

Using the system, real-time interaction between doctor and patient was facilitated, so as to detect alarming situations, and also to optimize the recovery program according to the patients evolution.

The devices for measuring vital parameters have been configured to send information automatically after being connected, to the Android smartphone via Bluetooth. Data collected on Smartphone were subsequently transmitted through 3G or WiFi, at the monitoring center in Cardiology Clinic of "Carol Davila" University within "Bagdasar Arseni" Emergency Hospital, where the medical staff in the intensive care unit monitored the patients evolution.

In case of detecting any abnormal values in measured parameters, the patient was contacted immediately by a doctor to check its status, eliminate false positives and to agree with the way of managing the situation. The mobile solution offered patients the possibility in case of a subjective symptomatology to manually trigger an alarm.

At the end of the 7 weeks of recovery a new ECG treadmill stress test was performed on all patients, in order to quantify exercise fitness levels evolution, changes in work capacity and their possibility to resume all normal daily activities.

Results and discussion

Statistical analysis in the frame of the study was performed using Microsoft Excel and SPSS programme, aiming initially to compare the two groups, followed by the health evolution assessment.

Patient groups comparison at the time of initial enrolment into the study was performed in order to verify that they are comparable in terms of qualitative and quantitative variables

Group 1 - patients that followed the online monitored cardiac rehabilitation;

Group 2 - patients that followed the individual unmonitored ambulatory rehabilitation.

The first step consisted in the analysis of distribution by gender, age, weight, height, body mass index, dyslipidaemia, hypertension, diabetes and smoking in the two groups that were studied (Table 1).

Table 1.1 Cardiac rehabilitation patients – descriptive data

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Age(years)	1	32	53.38	8.99	1.589
	2	37	54.3	9.62	1.582
Initial weight (Kg)	1	32	84.79	17.099	3.023
	2	37	83.32	12.049	1.981
Height (cm)	1	32	172.75	7.919	1.4
	2	37	172.73	5.796	0.953
Initial total fat (%)	1	32	33.916	9.7355	1.721
	2	37	32.549	8.6924	1.429
Initial visceral fat (%)	1	32	12.25	5.118	0.905
	2	37	13	3.223	0.53
Initial muscle mass (%)	1	32	29.763	5.4636	0.9658
	2	37	29.516	5.3743	0.8835
Body mass index	1	32	2.83E+01	4.92E+00	8.69E-01
	2	37	2.78E+01	3.27E+00	5.37E-01
Body surface(m2)	1	32	1.98E+00	2.08E-01	3.68E-02
	2	37	1.97E+00	1.58E-01	2.60E-02
Initial EF (simpson biplan)	1	32	47.28	5.018	0.887
	2	37	46.32	5.926	0.974
Initial PWV(m/s)	1	32	8.46	1.087	0.192
	2	37	8.01	1.126	0.185
Stress test activity(minutes)	1	32	8.3363	1.927	0.34065
	2	37	8.34	1.765	0.29016
Initial max HR(bpm)	1	32	147.66	11.705	2.069
	2	37	147.76	8.852	1.455
Initial max sistolic BP(mmHg)	1	32	185.94	18.467	3.265
	2	37	184.05	19.07	3.135
Initial max diastolic BP(mmHg)	1	32	87.5	9.837	1.739
	2	37	88.11	8.768	1.441
Initial estim VO2 max(ml/Kg*min)	1	32	29.3427	6.533638	1.154995
	2	37	29.51689	5.830923	0.958598

After analysing the characteristics of both groups using "Crosstabs" based on sex, presence of hypertension, dyslipidaemia, diabetes and smoking, it was observed that both groups had a similar structure. These results facilitated a proper statistical analysis of the evolution of health after performing the 7 weeks of cardiac rehabilitation program.

Data distribution testing revealed a generally Gaussian distribution, which allowed comparison of means between the two groups (Table 2).

Table 2.2 Cardiac rehabilitation – data distribution review

Independent Samples Test										
Initial assesment		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Age(years)	Equal variances assumed	0.398	0.530	-0.409	67.000	0.684	-0.922	2.253	-5.420	3.575
	Equal variances not assumed			-0.411	66.577	0.682	-0.922	2.242	-5.398	3.553
Initial weight (kg)	Equal variances assumed	3.174	0.079	0.416	67.000	0.679	1.466	3.526	-5.571	8.503
	Equal variances not assumed			0.406	54.661	0.687	1.466	3.614	-5.777	8.710
Height(cm)	Equal variances assumed	5.010	0.029	0.012	67.000	0.990	0.020	1.656	-3.285	3.326
	Equal variances not assumed			0.012	56.023	0.990	0.020	1.693	-3.372	3.413
Total Fat(%)	Equal variances assumed	1.548	0.218	0.616	67.000	0.540	1.367	2.219	-3.061	5.795
	Equal variances not assumed			0.611	62.783	0.543	1.367	2.237	-3.104	5.838
Visceral Fat(%)	Equal variances assumed	3.618	0.061	-0.738	67.000	0.463	-0.750	1.016	-2.777	1.277
	Equal variances not assumed			-0.715	50.771	0.478	-0.750	1.048	-2.855	1.355
Muscle mass(%)	Equal variances assumed	0.092	0.763	0.188	67.000	0.851	0.246	1.307	-2.363	2.856
	Equal variances not assumed			0.188	65.247	0.851	0.246	1.309	-2.368	2.860
Body mass index	Equal variances assumed	1.979	0.164	0.470	67.000	0.640	0.467	0.993	-1.516	2.449
	Equal variances not assumed			0.457	52.601	0.650	0.467	1.022	-1.583	2.517
Body surface(m2)	Equal variances assumed	4.016	0.049	0.273	67.000	0.786	0.012	0.044	-0.076	0.100
	Equal variances not assumed			0.268	57.420	0.790	0.012	0.045	-0.078	0.102
EF(Biplan Simpson) (%)	Equal variances assumed	0.816	0.370	0.718	67.000	0.476	0.957	1.334	-1.705	3.619
	Equal variances not assumed			0.726	66.976	0.470	0.957	1.317	-1.673	3.587
Pulse wave velococity(m/s)	Equal variances assumed	0.257	0.614	1.678	67.000	0.098	0.449	0.268	-0.085	0.983
	Equal variances not assumed			1.683	66.175	0.097	0.449	0.267	-0.084	0.982
Stress test activity (minutes)	Equal variances assumed	0.054	0.817	-0.008	67.000	0.993	-0.004	0.445	-0.891	0.884
	Equal variances not assumed			-0.008	63.513	0.993	-0.004	0.447	-0.898	0.890
Max HR(bpm)	Equal variances assumed	2.786	0.100	-0.041	67.000	0.968	-0.101	2.479	-5.050	4.849
	Equal variances not assumed			-0.040	57.200	0.968	-0.101	2.530	-5.166	4.965
Max sistolic BP(mmHg)	Equal variances assumed	0.013	0.909	0.415	67.000	0.679	1.883	4.537	-7.172	10.939
	Equal variances not assumed			0.416	66.120	0.679	1.883	4.526	-7.153	10.920
Max diastolic BP(mmHg)	Equal variances assumed	0.780	0.380	-0.272	67.000	0.787	-0.608	2.240	-5.079	3.863
	Equal variances not assumed			-0.269	62.731	0.789	-0.608	2.259	-5.122	3.906
Estimated VO2 max (ml/Kg*min)	Equal variances assumed	0.103	0.749	-0.117	67.000	0.907	-0.174	1.489	-3.145	2.797
	Equal variances not assumed			-0.116	62.770	0.908	-0.174	1.501	-3.174	2.825

After analysing the two groups, they were identified as being comparable to the time of initial evaluation, and showed no significant statistical differences (Table 3).

To assess the evolution of the health status of both groups, we used the comparison of the variables collected between the two points in time, the initial one before starting the home rehabilitation program and 7 weeks after, at the end of the recovery period. The statistical analysis of groups comparison was performed the "paired t-test". Comparisons were made to highlight the evolution of weight, total body fat, visceral fat, muscle mass and body mass index.

Table 3. Cardiac rehabilitation – groups comparison

Initial assesment	Grup	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Age(years)	1	0.105	32	.200*	0.961	32	0.296
	2	0.114	37	.200*	0.939	37	0.042
Initial weight (kg)	1	0.13	32	0.185	0.896	32	0.005
	2	0.102	37	.200*	0.969	37	0.386
Height(cm)	1	0.136	32	0.141	0.923	32	0.025
	2	0.141	37	0.062	0.969	37	0.376
Total Fat(%)	1	0.147	32	0.074	0.92	32	0.021
	2	0.151	37	0.033	0.937	37	0.037
Visceral Fat(%)	1	0.179	32	0.011	0.854	32	0.001
	2	0.162	37	0.015	0.902	37	0.003
Muscle mass(%)	1	0.122	32	.200*	0.934	32	0.051
	2	0.136	37	0.079	0.926	37	0.017
Body mass index	1	0.17	32	0.019	0.81	32	0
	2	0.101	37	.200*	0.973	37	0.493
Body surface(m2)	1	0.145	32	0.085	0.939	32	0.071
	2	0.084	37	.200*	0.969	37	0.393
EF(Biplan Simpson) (%)	1	0.146	32	0.082	0.955	32	0.195
	2	0.116	37	.200*	0.954	37	0.133
Pulse wave velococity(m	1	0.092	32	.200*	0.977	32	0.71
	2	0.166	37	0.011	0.945	37	0.068
Stress test activity(minut	1	0.093	32	.200*	0.959	32	0.25
	2	0.11	37	.200*	0.95	37	0.096
Max HR(bpm)	1	0.135	32	0.143	0.952	32	0.159
	2	0.09	37	.200*	0.97	37	0.416
Max sistolic BP(mmHg)	1	0.157	32	0.043	0.933	32	0.047
	2	0.152	37	0.031	0.945	37	0.066
Max diastolic BP(mmHg)	1	0.34	32	0	0.748	32	0
	2	0.282	37	0	0.802	37	0
Estimated VO2 max(ml/K	1	0.07	32	.200*	0.977	32	0.719
	2	0.125	37	0.157	0.962	37	0.226

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

For the group of patients that performed online home rehabilitation, there were found significant differences in the means of improvement of measured parameters, from initial to the final assessment for all parameters, except height, which as expected, is not affected. Among the group of those who performed classical cardiac recovery, unmonitored, varied statistically significant only the muscle mass, otherwise showed no significant variations in average, from baseline to the end (Table 4).

Table 4. Cardiac rehabilitation- group comparison on pairs

Group			Paired Differences					t	df	Sig. (2-tailed)
						95% Confidence Interval of the Difference				
			Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Online Rehabilitation 1	Pair 1	Initial-final weight	3.106	3.387	0.599	1.885	4.328	5.187	31.000	0.000
	Pair 3	Initial-final total fat	1.931	1.412	0.250	1.422	2.440	7.736	31.000	0.000
	Pair 4	Iinitial-final visceral fat	1.281	1.198	0.212	0.849	1.713	6.051	31.000	0.000
	Pair 5	Initial-final muscle mass	-1.597	1.083	0.191	-1.987	-1.207	-8.344	31.000	0.000
	Pair 6	Initial-final BMI	1.048	1.184	0.209	0.622	1.475	5.010	31.000	0.000
Noninstitutionalised rehabilitation 2	Pair 1	Initial-final weight	0.230	1.470	0.242	-0.260	0.720	0.951	36.000	0.348
	Pair 3	Initial-final total fat	-0.016	0.837	0.138	-0.295	0.263	-0.118	36.000	0.907
	Pair 4	Iinitial-final visceral fat	0.000	0.667	0.110	-0.222	0.222	0.000	36.000	1.000
	Pair 5	Initial-final muscle mass	0.295	0.668	0.110	0.072	0.517	2.681	36.000	0.011
	Pair 6	Initial-final BMI	0.069	0.490	0.081	-0.094	0.233	0.862	36.000	0.394

The second set of comparisons was made to highlight the evolution of changes made to the medical parameters measured by echocardiography, effort supervised ECG testing and analysis of pulse wave velocity and arterial stiffness.

There was a significant improvement of all parameters measured in the group of patients that performed the online cardiac rehabilitation, with improved ejection fraction (average growth of 5%), increase of the estimated cardiopulmonary capacity during effort (average growth of 8%) and a decrease of the vascular stiffness (average 0.02%).

In the group of control patients, which carried noninstitutionalized phase of cardiac rehabilitation, the monitored parameters were not significantly altered, except the maximum heart rate during effort, which had a slight increase, fact that could be associated with cardiovascular fitness deconditioning and an unfavourable prognosis for the patient (Table 5).

Table 5.3 Cardiac rehabilitation – comparison of medical variables

Paired Samples Test

Group			Paired Differences					t	df	Sig. (2-tailed)
						95% Confidence Interval of the Difference				
			Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Online Rehabilitation 1	Pair 1	Initial-final body surface	0.030	0.028	0.005	0.020	0.040	5.965	31.000	0.000
	Pair 2	Initial-final EF	-2.531	1.367	0.242	-3.024	-2.038	-10.471	31.000	0.000
	Pair 3	Initial-final PWV	0.188	0.154	0.027	0.132	0.243	6.888	31.000	0.000
	Pair 4	Initial-final max HR	-1.594	1.563	0.276	-2.157	-1.030	-5.769	31.000	0.000
	Pair 5	Initial-final max sisBP	4.688	8.418	1.488	1.652	7.723	3.150	31.000	0.004
	Pair 6	Initial-final max diastBP	3.125	5.351	0.946	1.196	5.054	3.304	31.000	0.002
	Pair 7	Initial-final estim VO2max	-2.386	1.256	0.222	-2.839	-1.933	-10.746	31.000	0.000
Noninstitutionalised rehabilitation 2	Pair 1	Initial-final body surface	0.002	0.015	0.002	-0.003	0.007	0.759	36.000	0.453
	Pair 2	Initial-final EF	-0.027	0.928	0.152	-0.336	0.282	-0.177	36.000	0.860
	Pair 3	Initial-final PWV	-0.011	0.084	0.014	-0.039	0.017	-0.780	36.000	0.440
	Pair 4	Initial-final max HR	-0.649	1.767	0.291	-1.238	-0.059	-2.233	36.000	0.032
	Pair 5	Initial-final max sisBP	-0.270	6.449	1.060	-2.421	1.880	-0.255	36.000	0.800
	Pair 6	Initial-final max diastBP	0.270	3.717	0.611	-0.969	1.509	0.442	36.000	0.661
	Pair 7	Initial-final estim VO2max	0.742	3.791	0.623	-0.522	2.006	1.191	36.000	0.241

Looking ahead and pursuing the development trend of technological solutions in recent years, with the concomitant fall of their prices, this alternative can be proposed as a recovery solution subsidized by the state, for a health system that cannot afford to cover the costs of standardized recovery, institutionalized in ambulatory manner, in specialized centres for patients who have suffered a cardiovascular event.

A long term randomized controlled study of cost efficiency and scalability, on a larger number of users of the online cardiac rehabilitation system, could prove the large-scale viability of the solution, with its subsequent implementation at regional or national level.

The current telemonitoring solution could be also refined for patients with other chronic diseases, such as diabetes mellitus, chronic liver disease or undergoing haemodialysis that have an increased risk of cardiac problems (NECHITA AM & al [18]. These patients would benefit greatly from such a system, as they require a close follow-up.

In order to increase patient education and interaction with the caregiver, a telemonitoring solution can be proposed in oncology in order to facilitate the patients the opportunity to recognise early symptoms in head and neck cancers. Novel and minimal invasive diagnostic and surgical techniques (STEFANESCU DC & al [15], STEFANESCU DC & al [16] , IMRE &al [17]) allow for limited resection and superior overall outcome, but the patients need to have a proper level of medical education.

For accurate monitoring of such patients we are taking into account the implementation of a new module of clinical investigations storage and progressive big data analytics on them. Endoscopic images could be uploaded using the future module in order to monitor the evolution of the patient. White light endoscopy, Narrow Band Images or SPIES images could also be used, but further research related to the design of the platform is required. However, ethical issues must be taken into account, concerning any possible liabilities (PITURU S at al [18, 19].

Conclusions

The objectives of the current research were to develop, integrate and test an easy to use mobile solution dedicated for cardiac patients, to guide them throw their rehabilitation process after an acute cardiac event.

Using interactive graphic interfaces with capabilities to automatically collect vital parameters from bluetooth connected medical devices, we checked if such a solution could be an enjoyable tool that by using real time monitoring and rapid interaction with the health care personnel can ensure an efficient cardiac rehabilitation process for patients with myocardial infarction.

From the medical perspective, the solution provided superior results in comparison with the noninstitutionalised rehabilitation offering a statistical significant improvement ($p<0.05$) of all clinical parameters measured in the group of patients that performed the online cardiac rehabilitation, with improved ejection fraction (average increase of 5% of the initial cardiac function), increase of the estimated cardiopulmonary capacity during effort (average increase of 8%) and a decrease of the vascular stiffness (average 0.02%)

The use of the online cardiac rehabilitation system in an ambulatory setting, brings multiple benefits to all actors involved in the process:

The medical caregiver:

a. can manage more patients
b. receives alarms from the patient, acting rapidly on vital moments
c. monitors the effectiveness of medication by tracking vital parameter values
d. adjusts remotely when needed, the recovery plan

The patient:

a. can benefit of a cardiac rehabilitation program in an environment more comfortable than in specialized facilities
b. may announce at any time there is a troublesome symptomatology, can follow the evolution in terms of measurements taken during recovery, by tracking history
c. acquires a sense of confidence and self-care by automatically determining the measurements, which are transmitted to the monitoring centre

In comparison with the noninstitutionalised rehabilitation this innovative type of rehabilitation offers freedom in planning the daily rehabilitation activities, so, the chances for long life implementation of regular physical activity and other healthy habits increase.

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Declaration of conflicting interests

The Authors declare that there is no conflict of interest.

References

1. WILKINS E, WILSON L, WICKRAMASINGHE K, BHATNAGAR P, LEAL J, LUENGO-FERNANDEZ R, BURNS R, RAYNER M TN. European Cardiovascular Disease Statistics 2017 edition . Brussels; 2017.
2. PIEPOLI MF, CORRA U, DENDALE P, FREDERIX I, PRESCOTT E, SCHMID JP. Challenges in secondary prevention after acute myocardial infarction: A call for action. Eur J Prev Cardiol. SAGE PublicationsSage UK: London, England; 2016 Dec 1;23(18):1994–2006.
3. PIEPOLI MF, HOES AW, AGEWALL S, ALBUS C, BROTONS C, CATAPANO AL. 2016 European Guidelines on cardiovascular disease prevention in clinical practice. Eur J Prev Cardiol. 2016 Jul; 23(11):NP1-NP96.
4. PONIKOWSKI P, VOORS AA, ANKER SD, BUENO H, CLELAND JGF, COATS AJS. Wytyczne ESC dotyczące diagnostyki i leczenia ostrej i przewlekłej niewydolności serca w 2016 roku. Kardiol Pol [Internet]. 2016 Oct 13;74(10):1037–147.
5. ECKEL RH, JAKICIC JM, ARD JD, DE JESUS JM, HOUSTON MILLER N, HUBBARD VS. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. Circulation [Internet]. 2014 Jun 24;129(25 Suppl 2):S76-99.
6. ANDERSON L, OLDRIDGE N, THOMPSON DR, ZWISLER A-D, REES K, MARTIN N. Exercise-Based Cardiac Rehabilitation for Coronary Heart Disease. J Am Coll Cardiol. 2016 Jan 5;67(1):1–12.
7. KOTSEVA K, WOOD D, DE BACQUER D, DE BACKER G, RYDÉN L, JENNINGS C. EUROASPIRE IV: A European Society of Cardiology survey on the lifestyle, risk factor and therapeutic management of coronary patients from 24 European countries. Eur J Prev Cardiol [Internet]. 2016 Apr; 23(6):636–48. Available from: http://www.ncbi.nlm.nih.gov/pubmed/ 25687109
8. The Broadband Commission for Digital Development. The State of Broadband 2015 [Internet]. Geneva; 2015.
9. WALSH JA, TOPOL EJ, STEINHUBL SR. Novel Wireless Devices for Cardiac Monitoring. Circulation. 2014;130(7).
10. WIDMER RJ, ALLISON TG, LERMAN LO, LERMAN A. Digital Health Intervention as an Adjunct to Cardiac Rehabilitation Reduces Cardiovascular Risk Factors and Rehospitalizations. J Cardiovasc Transl Res. Springer US; 2015 Jul 7;8(5):283–92.
11. Health Research Institute P. Healthcare's new entrants: Who will be the industry's Amazon.com? [Internet]. 2014. Available from: www.pwc.com/us/hri
12. FREDERIX I, VANHEES L, DENDALE P, GOETSCHALCKX K. A review of telerehabilitation for cardiac patients. J Telemed Telecare [Internet]. 2015 Jan;21(1):45–53. Available from: http://www.ncbi.nlm.nih.gov/pubmed/25475219
13. KULCSAR I, GAITA D. Country report Romania – April 2016 Baseline Information about Romania. 2016;(April).
14. FI-STAR Consortium. FI-STAR Description of Work. FI-STAR Consortium, editor. 2014.
15. STEFANESCU DC ; CEACHIR, O; ZAINEA, V ; HAINAROSIE, M; PIETROSANU, C; IONITA, IG; HAINAROSIE, R. The Value of Toluidine Blue Staining Test in Assessing Disease Free Margins of Oral Cavity Carcinomas. Revista de Chimie, 2016, 67(7): 1255-1256.
16. STEFANESCU DC; CEACHIR, O; ZAINEA, V; HAINAROSIE, M; PIETROSANU, C; IONITA, IG; HAINAROSIE, R. The Use of Methylene Blue in Assessing Disease Free Margins During CO2 LASER Assisted Direct Laryngoscopy for Glottis Cancer. Revista de Chimie, 2016, 67(7): 1327-1328.
17. M. MELEȘCANU IMRE , A. CELIBIDACHE , A.M.C. ȚÂNCU, M. PANTEA , I. SUCIU , P. PERLEA. Laser's applications in minimally invasive dental procedures – new trends in modern dentistry. *Rom Biotechnol Lett* 23 (6): 14109- 14115 (2018)
18. PITURU S, VLADAREANU S, PAUN S, NANU A. Malpractice and professional liability of medical personnel. Farmacia, 2015, 63(2): 318-324.
19. NECHITA AM, PITURU S, RADULESCU D, PERIDE I, NEGREANU L, NICULAE A, FERECHIDE D, CHECHERITA IA, SINESCU RD. Influence of residual diuresis on cardiac biomarker NTproBNP in chronic hemodialysis patients. Farmacia, 2016, 64(3): 348-357.