Telecardiology for patients with chronic heart failure: 
the ‘SHL’ experience in Israel

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Abstract

Background: Patients with chronic heart failure characteristically have multiple hospital admissions for symptom control, deleteriously affecting their quality of life and imposing a burden on national healthcare costs. We assessed the effect of a novel transtelephonic monitoring and follow-up program on the admission rate and length of hospital stay as well as changes in their subjectively rated quality of life of patients with chronic heart failure. Methods: This prospective 1-year study was conducted on compliant subscribers to ‘SHL’, a telecardiological service with >60,000 subscribers, who were admitted ≥ 2 times during the previous year for recurrent pulmonary edema or deterioration in heart failure. Their heart rate, blood pressure and body weight measurements were now automatically transmitted daily to ‘SHL’s data bank and added to stored and updated medical records. A questionnaire survey acquired information on their quality of life. Results: The study cohort included 118 patients, mean age 75 years (range 49–89 years), 65% males, a II–IV class functional capacity and a 25% (range 10–39%) mean ejection fraction. There was a 66% reduction in the total hospitalization days (from 1623 in the year preceding study entry to 558 during the study period, \( p < 0.0001 \)). Although only 38/118 patients were hospitalized, most participants reported a significant subjective improvement in their quality of life. Conclusions: Data are provided to demonstrate that a transtelephonic system allowing primary care at the patient’s home can significantly reduce hospitalization rate and length of stay and significantly enhance the quality of life of patients with chronic heart failure. © 2003 Elsevier Ireland Ltd. All rights reserved.

Keywords: Telemedicine; Heart failure; Quality of life

1. Introduction

Heart failure, which affects an estimated 4.7 million Americans with more than 500,000 new cases diagnosed annually, is associated with high rates of morbidity and mortality. Many patients also undergo deterioration in their quality of life because of physical symptoms that disrupt normal daily functioning. Enormous costs stemming from huge numbers of hospitalizations and re-admissions, which may approach 50% by 6 months, confer a daunting economic burden as well. With the advancement in telecommunication devices in recent years, the ever-vigilant technologists were not long in picking up the gauntlet in the search for cutting-edge alternatives for the provision of better care at lower cost. It is, therefore, not surprising that expert groups have recommended increasing the involvement of home health services in the care of patients with chronic heart failure [1–3]. This recommendation is based on the presumption that home healthcare nurses, for instance, will reduce hospitalization rates by educating patients about heart failure, increasing patient compliance, and detecting clinical deterioration. Healthcare providers and funding plans are also finding that these innovations can help to curb costs without imposing further risk to the patient.

This study aimed to assess whether the application of a daily telecardiological program, ‘SHL-CHF’, could reduce the number of hospitalizations and improve the quality of

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life of patients with chronic heart failure as well as to decrease the national health costs for these patients.

2. Materials and methods

2.1. The system

The medical facility ‘SHL’, which incorporates telecardiological and face-to-face professional medical assistance to its >60,000 subscribers, was already described in detail elsewhere [4,5]. Briefly, it operates through a monitoring center managed by intensive care nurses who dispatch mobile intensive care units staffed by physicians and paramedics to subscribers. Each subscriber’s complete medical file (which also includes a 12-lead electrocardiogram) is stored in a central computer and the records are updated continuously. All the members carry a cardiobeeper by which they can transmit a 3-lead (I, II, III) or a 12-lead electrocardiogram via a regular household telephone. Once a name or identification number identifies the caller, the appropriate medical file is immediately displayed on a computer screen from which the nurse retrieves all the pertinent facts in addition to a real-time transtelephonic anamnesis. After interpreting the transmitted electrocardiographic (ECG) data, and based on written protocols, the nurse may either dispatch a mobile intensive care unit to the patient, consult the physician either on-call or present at the center, or provide the patient with established medical or behavioral instructions.

2.2. Patient population

For the current study, ‘SHL’’s medical files were screened for patients whose primary diagnosis was chronic heart failure, and letters describing the program were then sent to potential candidates. After obtaining their consent to participate, their personal physicians (general practitioners, internists or cardiologists) were contacted by telephone in order to obtain their agreement as well.

2.3. Inclusion criteria

(a) Patients with chronic heart failure clinical class II–IV due to systolic left ventricular dysfunction with complaints of shortness of breath at rest or during exercise and by objective evidence of cardiac dysfunction as manifested by cardiac echocardiography or isotope or contrast ventriculography
(b) Mental and physical capability to cooperate by following and performing all the steps and procedures as set down by the protocol
(c) Patients who had at least two documented hospitalizations for exacerbation or worsening of heart failure during the preceding year
(d) Age up to 90 years
(e) Possessing a functioning telephone line

2.4. Exclusion criteria

(a) Inability or refusal of the patient to consent or noncompliance of his physician
(b) Unstable clinical and/or hemodynamic condition
(c) Acute myocardial infarction within the last 8 weeks
(d) End-stage renal failure/dialysis or significant co-morbid conditions compromising prognosis or functional capacity
(e) Rheumatic heart disease, hypertrophic or restrictive cardiomyopathy
(f) Planned cardiac surgery

2.5. Equipment

Apart from the above-mentioned devices regularly supplied to ‘SHL’ subscribers, each participant was equipped with an electronic scale and a blood pressure measuring device with a cuff which easily slips on with one hand, both connected to ‘SHL’ via a telephone line.

2.6. Study design and protocol

The study was designed to last 12 months from patient enrollment, and the ethics committee of ‘SHL’ approved the study protocol. Upon enrollment into the program, each participant’s weight was recorded to represent the baseline or reference weight. The patients were instructed to weigh themselves every morning (between 08.00 and 10.00) and to apply their blood pressure device (which measured their pulse rate at that time as well). All these values were automatically transmitted to the ‘SHL’ center when the patient stepped off the scale, without the need to otherwise contact the center.

An algorithm based on automatic comparisons of data for the same patient was installed in the center’s computer database. If there had been no changes from baseline values, the fresh data were added to the medical file and no further steps were taken. If, however, a predetermined critical shift from baseline values had occurred, the center would be alerted by an instantaneous message appearing on the center’s monitors alerting the staff; the duty nurse would then display the patient’s data in a quick, easily read format and the results could be expeditiously correlated with current medications. In such an alarm state, the nurse would immediately telephone the patient and, after confirmation of his subjective well being, he was asked to repeat the same three measurements.

The major shifts which would sound an alarm were: (a) an increase of 1.5 kg in weight compared to baseline and/or systolic blood pressure exceeding 180 mm Hg and/or diastolic blood pressure exceeding 110 mm Hg or systolic blood pressure lower than 90 mm Hg; (b) no submission of
data by the patient for three consecutive days. In addition, the monitor center’s nurse telephoned the patient once every 2 weeks for assurance of his well being, close symptom surveillance, updating of treatment, promoting adherence to treatment, reminding him to restrict salt intake and encourage compliance with the program.

The nurse always followed a standardized format to probe for subtle indicators of side effects from the medications or those of heart failure progression by asking questions which targeted two objective symptoms (palpitations and sleep disturbances) and two subjective symptoms (dizziness and change in daily lifestyle). Each positive reply resulted in the generation of a list of questions and possibilities directly related to the patient’s answers. The list was displayed automatically on the computer screen together with suggestions for the appropriate responses and measures to take.

If the call elicited two or more positive replies but not of the type that necessitated any prompt medical intervention, an automatic alarm to call again in 3 days was programmed into the system. In the case of new or worsening symptoms, the computer was programmed to increase the frequency of telephone contacts. If indicated according to established guidelines, the patient’s physician was informed of these changes, either directly by the center or by the patient himself.

In addition, each unscheduled call which arrived to the monitor center was attended to according to the routine standing orders as warranted.

2.7. Quality of life

Another questionnaire filled out by telephone interviews once every 4 months dealt with quality of life issues. In addition to the routine detailed medical history taken from the patient by a physician, an eight-item questionnaire graded according to the patient’s answers (“better”, “no change”, “worse”) was filled out by the interviewer (physician or nurse). It included the following areas of interest:

(a) How the patient would generally describe his quality of life
(b) Willingness to stay home alone
(c) Willingness to leave home alone
(d) Willingness to go to work
(e) Quality of relationships with close family members
(f) Quality of relationships with close friends
(g) Self-evaluation of efficiency at work
(h) Economic situation in general

2.8. Response to alarm

2.8.1. Increase in weight

A dose of oral furosemide 40–80 mg was recommended to the patient in addition to the current treatment. If the patient was still in the “alarm zone” on the following day, a double dose of furosemide was given. If the patient still sounded the alarm on the day after that, a mobile unit was dispatched for the intravenous administration of 100–250 mg furosemide. Each administration of furosemide was accompanied by a dose of oral potassium chloride, which was equivalent to the dose used by the patient on a regular basis.

2.8.2. Increase or decrease in blood pressure

This was handled according to ‘‘SHL’’s routine standing orders which implied advancing the ingestion of his anti-hypertensive medication or skipping a dose in the case of hypotension and providing reassurance as warranted.

2.9. Follow-up

A special file was established in the center’s computer for the purpose of prospectively following up all activities of the study cohort throughout 1 year. The specific data that were collected and entered were the patient’s identification number, dates and length of any hospitalizations during the study period, alterations in medications for heart failure, mortality and cause of death (the latter was obtained from hospital discharge or mortality reports or contacts with family members and/or the attending physician if death occurred out of hospital).

2.10. Statistical analyses

Results are given as mean ± S.D. for continuous variables and proportions for discrete variables. Univariate analysis was performed using t tests, analysis of variance, chi-square analysis and the Pearson correlation test for continuous and discrete variables as appropriate. The two-way analysis of variance with repeated measures was performed for the detection of time trends and comparison between groups. Multivariate stepwise regression analyses were performed for the detection of various variables which could affect the need for hospitalizations. Because not all patients completed 12 months of follow-up, calculations and analyses were done per month whenever applicable. A p value < 0.05 was considered statistically significant in the analyses of the results.

3. Results

3.1. General

Of the 163 patients who fulfilled the inclusion criteria, 45 were subsequently excluded (16 were incapable of carrying out the procedures, 22 were unwilling to participate, and the physicians of the remaining 7 refused to participate). Table 1 lists the demographic characteristics and co-morbid illnesses of the final 118-patient study cohort.

Fifteen (15/118, 13%) patients (mean age 77 years, range 64–93) died during the 12-month study period, and all but
Table 1
Selected demographic and clinical data of the 118 study patients

<table>
<thead>
<tr>
<th>Male/female (n)</th>
<th>82/36</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y (± 1 S.D.)</td>
<td>74 ± 9 (range 47–89)</td>
</tr>
<tr>
<td>Ejection fraction, % (± 1 S.D.)</td>
<td>24 ± 7 (range 10–40)</td>
</tr>
<tr>
<td>NYHA functional status (n)</td>
<td></td>
</tr>
<tr>
<td>Class II</td>
<td>26</td>
</tr>
<tr>
<td>Class III</td>
<td>46</td>
</tr>
<tr>
<td>Class IV</td>
<td>46</td>
</tr>
<tr>
<td>Post myocardial infarction (n)</td>
<td>75</td>
</tr>
<tr>
<td>Post CABG (n)</td>
<td>41</td>
</tr>
<tr>
<td>Diabetes (n)</td>
<td>49</td>
</tr>
<tr>
<td>Hypertension (n)</td>
<td>8</td>
</tr>
<tr>
<td>Dilated cardiomyopathy (n)</td>
<td>43</td>
</tr>
<tr>
<td>Medical treatment (%)</td>
<td></td>
</tr>
<tr>
<td>Aldactone</td>
<td>100</td>
</tr>
<tr>
<td>Including spironolactone</td>
<td>30</td>
</tr>
<tr>
<td>ACE inhibitors</td>
<td>49</td>
</tr>
<tr>
<td>Antiplatelet and/or anticoagulants</td>
<td>46</td>
</tr>
<tr>
<td>Beta blockers</td>
<td>37</td>
</tr>
<tr>
<td>Nitrates</td>
<td>28</td>
</tr>
<tr>
<td>Digoxin</td>
<td>25</td>
</tr>
<tr>
<td>Calcium blockers</td>
<td>13</td>
</tr>
<tr>
<td>Alfa blockers</td>
<td>4</td>
</tr>
</tbody>
</table>

CABG, coronary artery bypass grafting.

one were in NYH classes III–IV. Six patients died of cardiac reasons (three underwent sudden death at home) and nine patients died of non-cardiac-related disease. Twenty-three patients were withdrawn from the study for technical reasons (mean time to withdrawal 4.2 months, range 1.5–10).

3.2. Hospitalizations

The total number of days of hospitalizations for chronic heart failure among the study participants decreased from 1623 in the year preceding study entry to 558 during the study period \((p < 0.0001)\). Only 38 of the 118 study patients were hospitalized, and all their admissions without exception were considered as being medically justified. There was a decrease in the number of hospitalizations for all NYHC functional groups and it correlated inversely with disease severity: it was 82% (from 0.22 hospitalizations per month per patient to 0.04) for class II, 75% (from 0.20 to 0.05) for class III and 57% (from 0.28 to 0.12) for class IV.

The mean length of stay for the entire cohort decreased from 13.75 in the year before study entry to 3.06 during the study period \((p < 0.0001)\). The inclusion of the data on the patients who did not complete the 1-year study period in the calculations made for each patient per month, however, resulted in a decrease from 1.15 days/month in the year prior to the study to 0.39 days/month during the study period \((p < 0.0001)\).

3.3. Hospitalization and demographic variables

The study patients who were hospitalized had a significantly \((p = 0.042)\) lower body mass index, and the percentage of females among them tended to be higher compared with those who were not hospitalized \((44\% \text{ versus } 27\%, \text{ respectively, } p = 0.059)\). There was a trend for smokers to be admitted more than nonsmokers \((p = 0.062)\). Diabetics had significantly more hospitalizations \((49\%)\) than the non-diabetics \((25\%, p = 0.013)\), as did patients with a past myocardial infarction \((43\%)\) compared with those without one \((23\%, p = 0.027)\).

No association was found between the rate of re-hospitalization and the following: hypertension, hyperlipidemia, amount and dosage of drugs used, any revascularization procedure in the past or arrhythmias. Patients who had been re-hospitalized were in a poorer NYH \((p = 0.098\) between class IV and class II), but an ejection fraction either higher or lower than 20% made no difference in the number of hospitalizations.

A recommendation for an increase in dosage of oral furosemide was given 155 times for 66 patients and a mobile unit was dispatched to inject furosemide intravenously in 97 cases. Thirty-two of them \((48\%)\) ultimately required hospitalization while 11% \((6/52)\) whose dosage was not increased were hospitalized \((p < 0.0001)\).

3.4. Hospitalization and hemodynamic variables

A total of 2410 automatic alarms signaling blood pressure variations was recorded and 4.3% of them were made by those who were not hospitalized throughout the entire study period compared with 3.2% who were hospitalized at this or another stage. Although baseline systolic blood pressure measurements upon study recruitment were comparable between both groups, the former consistently had a higher recorded systolic blood pressure throughout the study period \((130 \text{ versus } 120 \text{ mm Hg})\). Additionally, it was characteristic for there to have been a further rise in systolic blood pressure on the day of admission. A similar increase on that day was also noted for diastolic blood pressure but, in contrast to systolic blood pressure, there was no difference in these values between hospitalized and non-hospitalized study participants.

No substantial correlation was found between heart rate and hospitalization, but there was a slight trend toward an increase in heart rate \((\text{mean increase of 7 beats/min, from 69 to 76 beats/min)}\) in the week preceding hospitalization.

A total of 4227 automatic alarms pertaining to weight were recorded, 12.8% by non-hospitalized patients and 14.1% by hospitalized patients. A significant increase in mean body weight was characteristic on the day of admission for hospitalized patients but not during the period of time preceding hospitalization. A more in-depth scrutiny of their weights throughout the 30 days before hospitalization, however, revealed a trend \((r = 0.200)\) toward an increase in weight. This trend further increased \((r = 0.305)\) as the time of hospitalization got closer (Fig. 1). Moreover, an analysis of the frequency of alarms for changes in body weight supported the finding of a trend towards more such alarms in the week preceding hospitalization.
3.5. Quality of life

A significant subjective improvement in this parameter was reported by most participants irrespective of hospitalization during the study. As might be expected, however, a trend toward greater satisfaction from improvement in quality of life was described by the non-hospitalized patients compared to the hospitalized ones ($p=0.059$). This improvement was already noted by 50% of the participants at 4 months into the study, while 36% reported no change and the other 14% felt that there was a subjective decline in their quality of life. At 8 months into the study, 71% of the participants reported a significant improvement compared to baseline and 29% on a worsening of their quality of life, while 91% of the surviving participants reported improvement and 9% worsening at 12 months (close of study). The question most significantly indicative of improvement in quality of life among all the questions of this trimester questionnaire was the one on the confidence to stay home alone (question “b”) to which most patients responded positively.

4. Discussion

Telehealth care is an emerging technology. Reports on its potential benefits for monitoring and treating chronic heart failure patients are sparse and none provide specific details on the financial consequences of its implementation. Our current report adds further information to the few existing publications that assess the impact of a telecardiological system on national costs of caring for these patients. We could do this by the availability of a large compliant patient cohort, a long period of follow-up (i.e., 1 year), and a wealth of data retrieved from a highly efficient and technically cutting-edge system in which primary care was commenced in the home setting.

4.1. Cooperation and tolerance

The “SHL-CHF” program gave both doctors and patients the vital feedback for obviating deterioration of the patient’s condition, and the level of their cooperation reflected the value they placed on these services. The average age of the patients was similar to that of heart failure patients generally found within the community, showing that advanced age is not necessarily a detriment to using the equipment. As had been shown in a similar investigation on 10 patients [6], compliance with measuring weight, pulse and blood pressure remained high throughout the study.

4.2. Clinical outcome

Although this study is statistically too underpowered to evaluate mortality issues and lacks a control group, it is noteworthy that overall mortality (15/118, 13%) and the factors attributing directly to the consequences of heart failure (7/118, 6%) were low. Whether this was due to early detection of fluid accumulation or changes in hemodynamics that led to prompt intervention or if these are incidental findings is not clear.

Our data demonstrated fewer hospitalizations resulting in fewer total days of hospitalization by implementing home-care strategies as shown earlier [1,3,7,8]. Our system, however, used a completely automatic mode of monitoring acquisition and processing of data, as did only de Lusignan et al. [6] on far fewer patients.

West et al. [9] described a home-based management system called MULTIFIT, supervised by doctors and practiced by nurses, which helps heart failure patients adhere to dietary and drug treatments through frequent telephone contact. Nurses tracked 51 patients for 138 days by telephone and were also available for those who needed help. There was a reduction in their patients’ sodium intake, improvement in medicine compliance and functionality, and a shorter total hospitalization period compared with the preceding year: a decline by 87% for heart failure and by 74% for all other causes.

4.3. Quality of life

Unlike the benefits of various therapeutic approaches, quality of life issues are generally not addressed and little information is available about the impact of home health care on this parameter. We devised a short straightforward questionnaire to elicit subjective feelings in this especially ill population. Most of the patients reported a general improvement, occurring as early as at 4 months into the program in 50% of them. The most highly affected aspect overall was the confidence to stay home alone or leave the

Fig. 1. Daily weight changes during the week preceding hospital admission (“0”) in 38/118 chronic heart failure patients participating in a 1-year telecardiological program.
We cannot explain the inverse relations of severity of disease with hospitalizations other than the numbers of hospitalized participants being too low to draw statistical conclusions. It may be speculated that the sicker the patient, the more compliant he will be to accept medical recommendations, and that his adherence to treatment prevented recurrent hospitalizations. The re-hospitalized study patients had an unexpectedly significantly ($p = 0.042$) lower body mass index than the others, a finding compatible with Horwich et al.’s [21] observation of not finding obesity to be associated with increased mortality and that it may even confer a more favorable prognosis in a large cohort of patients with advanced heart failure of multiple etiologies.

### 4.6. Study limitations

This study was open-labeled and nonrandomized. Ours was not a standard validated questionnaire for evaluating quality of life and may not have adequately addressed that issue.

### 4.7. Concluding remarks

The need for developing more effective strategies for patient management is an urgent one: we are in a race with time, given the increasing number of gravely ill patients within our aging population and the increasing strain on the healthcare system’s resources. Designing effective telecardiological strategies can save money and provide quality care. The ‘SHL-CHF’ program effectively helped to stem the deterioration of patients’ health, reduced their hospitalizations, reduced national health costs, and maintained the patient in a more comfortable and self-confident lifestyle at home.

### Acknowledgements

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### References


