Impact of a Comprehensive Heart Failure Management Program on Hospital Readmission and Functional Status of Patients With Advanced Heart Failure

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Objectives. To assess the impact of a comprehensive heart failure management program, functional status, hospital readmission rate and estimated hospital costs were determined and compared for the 6 months before and the 6 months after referral.

Background. The course of advanced heart failure is characterized by progressive clinical deterioration reflected in frequent hospital admissions, which comprise the major financial cost.

Methods. Over a 3-year period, 214 patients were accepted for heart transplantation and discharged after evaluation, which included adjustments in medical therapy and intensive patient education. Patients were in New York Heart Association functional class III or IV (94 and 120 patients, respectively), with a mean left ventricular ejection fraction of 0.21, peak oxygen consumption of 11 ml/kg per min and a total of 429 hospital admissions in the previous 6 months (average 2.0 per patient). Changes in the medical regimen included a 98% increase in angiotensin-converting enzyme inhibitor dose and a flexible diuretic regimen after 4.2-liter net diuresis, with counseling also regarding diet and progressive exercise.

Results. During the 6 months after referral, there were only 63 hospital readmissions (85% reduction), with 0.29/patient (p <

0.0001). Functional status improved as assessed by functional class (p < 0.0001) and peak oxygen consumption (15.2 vs. 11.0 ml/kg per min, p < 0.001). The same results were seen after excluding the 35 patients without full 6-month follow-up (9 deaths, 14 urgent transplant procedures during hospital readmission, 12 elective transplant procedures from home); 34 hospital admissions occurred after referral, compared with 344 before referral. Even when adding in the initial hospital admission after referral for these 179 patients, there was a 35% decrease in total hospital admissions in the 6-month period. The estimated savings in hospital readmission costs after subtracting the initial hospital costs for management was $9,800 per patient.

Conclusions. Comprehensive heart failure management led to improved functional status and an 85% decrease in the hospital admission rate for transplant candidates discharged after evaluation. The potential to reduce both symptoms and costs suggests that referral to a heart failure program may be appropriate not only for potential heart transplantation, but also for medical management of persistent functional class III and IV heart failure.

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Heart failure has emerged as a major public health problem, affecting more than 3 million patients in the United States (1). Almost one-third of these patients have New York Heart Association functional class III or IV heart failure, often characterized by progressive deterioration and frequent hospital admissions. Annual expenditures for heart failure have been estimated to be as high as $38 billion, of which $23 billion is for hospital stays (2). For Medicare alone, the heart failure costs exceed the costs for myocardial infarction or all types of cancer combined. The incidence of hospital admission for heart failure is increasing rapidly (3), and readmissions for heart failure occur within months of the index hospital period for over 30% of patients. Readmission costs consume a proportional share (30%) of the overall inpatient costs, and even more in patients with the greatest degree of chronic functional impairment.

Rational care for chronic heart failure integrates inpatient and outpatient health care delivery with a goal of maintaining improved clinical function and decreasing the need for hospital readmission. However, there is marked variation in the management of patients with heart failure (4,5). Overburdened

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Abbreviations and Acronyms

ACE = angiotensin-converting enzyme
LVEF = left ventricular ejection fraction
UCLA = University of California Los Angeles

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primary care practices report limited incorporation of results from randomized clinical trials. Unfamiliarity with medications and doses for heart failure or concern regarding potential side effects may lead to underutilization. Education regarding nonpharmacologic therapy such as diet and exercise requires staff time and commitment. Close tracking of relevant clinical and laboratory data may not be feasible, except for large groups of patients with similar diagnoses. Concentrated heart failure programs may be able to provide more focused care that could improve patient outcome and decrease hospital admissions, and thus costs. The purpose of this study was to assess the impact of a comprehensive management program incorporating a systematic approach to drug therapy, patient education about diet, exercise and self-monitoring and regular contact with the heart failure team.

Methods

Patient selection. The study group consisted of patients with severe heart failure referred to the Ahmanson–University of California at Los Angeles (UCLA) Cardiomyopathy Center as potential candidates for heart transplantation, between January 1, 1991 and March 1, 1994. All patients included in this study were in functional class III or IV heart failure for at least 6 months before referral. This analysis was confined to patients who were determined to be candidates for transplantation (sufficient indications without contraindications) (6) and were discharged to await heart transplantation on an elective basis.

Evaluation and management. At the time of referral, patients underwent a detailed initial assessment including review of all available medical records. The number of hospital admissions as well as the precipitating symptoms and admission diagnoses for all hospital stays in the 6 months before referral were determined by interviewing the patient and confirmed by reviewing the discharge summaries. Additional records were sought and the responsible admitting physicians interviewed if chart documentation was incomplete.

The medical regimen at the time of referral was carefully documented. Functional status at the time of referral was assessed by consensus of the heart failure cardiologist and heart failure clinical nurse specialist. Peak oxygen uptake was measured (MedGraphics CardiO$_2$) during cycle ergometry with a 6-min warm-up period followed by a brief rest, 2 min of unloading cycling and 15-W ramp to limiting symptoms, as previously described (7). All patients were urged to exercise beyond a respiratory quotient of 1.0 by a technician who had no knowledge of medication changes or status as a transplant candidate. For patients unable to perform exercise testing

initially, the baseline value was that from a test performed within the next 6 weeks after referral. Anaerobic threshold was estimated by the V-slope method and confirmed by ventilatory criteria. Left ventricular ejection fraction (LVEF) was estimated using two-dimensional echocardiography with the Simpson rule.

Medications. After initial assessment of possible eligibility for transplantation, 214 patients underwent formal evaluation for transplantation, which included right heart catheterization to determine pulmonary pressures. Patients with a pulmonary capillary wedge pressure >20 mm Hg or a cardiac index <2.2 liters/min per m^2 had the catheter left in place during further vasodilator and diuretic therapy, frequently with the initial use of nitroprusside, as described previously in transplant candidates (7,8). Unless patients demonstrated acute decompensation, hemodynamic monitoring was performed in an intermediate "step-down" unit with a lower nursing ratio and daily cost rather than in a standard intensive care unit. The oral regimen was based primarily on captopril (maximal dose of 400 mg/day) and isosorbide dinitrate (maximal dose of 180 mg/day) (9). Hydralazine was used in 7% of patients in whom additional vasodilation appeared to be needed or the angiotensin-converting enzyme (ACE) inhibitor was not tolerated.

The regimen of loop diuretic drugs was adjusted to achieve and then maintain the patient's daily weight to within 2 lb of the weight at which optimal hemodynamic data were achieved. Metolazone was added if necessary, but in general was reserved for intermittent use. Digoxin was continued in all patients who had previously been receiving digoxin and was initiated in patients without relative contraindications such as conduction system disease or fluctuating renal dysfunction. First-generation calcium channel blockers were generally discontinued, and nonsteroidal antiinflammatory agents were proscribed. Beta-adrenergic receptor antagonists were continued in four patients receiving them for angina or arrhythmias, but were not given as part of heart failure management. Anticoagulation with warfarin was prescribed for patients who had atrial fibrillation, previous embolic events or mobile intracardiac thrombus observed on the echocardiogram (10). Patients with atrial fibrillation or high grade, nonsustained ventricular tachycardia received low dose amiodarone (200 mg/day) after varied loading protocols. Type I antiarrhythmic agents for nonsustained ventricular tachycardia or atrial fibrillation were generally discontinued. No investigational agents were used.

Education. Patients and family members received comprehensive education taught in groups and individually by a heart failure clinical nurse specialist, reinforced with patient brochures. The flexible diuretic regimen included daily weights and a response to a 2-lb weight gain that included increased diuretic drugs and often increased potassium to be taken after diuresis was noted, with subsequent serum electrolyte measurements. Dietary guidelines usually included 2-g sodium restriction and, for patients on high dose diuretics, 2-liter fluid restriction. Complete abstinence from alcohol and smoking was emphasized. Patients did not undergo formal exercise

rehabilitation but were instructed to walk outside on flat ground or in a shopping mall or to use a stationary bicycle at least four times weekly, increasing to a target duration of 30 to 45 min. Patients were taught to check their heart rate and aim for a level close to that observed at the onset of anaerobic metabolism during their cardiopulmonary exercise test.

Patients and families were also advised of the uncertain prognosis and the risk of sudden death. They were given detailed instructions regarding warning symptoms of worsening heart failure and other complications such as arrhythmias or embolic events.

Care after discharge. Patients were followed by the heart failure cardiologists in conjunction with their referring physicians. Patients were contacted within 3 days of hospital discharge and seen weekly at the heart failure center until criteria for clinical stability were met (11). Telephone calls were made 2 to 3 days after any major medication change and at routine intervals between 2 and 8 weeks, as warranted by clinical stability, patient sophistication and need for reassurance. Patients were interviewed regarding symptoms and examined for any signs of fluid retention. The patient education program was reinforced during each visit, and the weight charts and exercise program were specifically reviewed. Diuretic regimens were adjusted for frequent weight gain or when postural hypotension or low jugular venous pressure suggested excessive diuresis. The ACE inhibitor doses prescribed at discharge were well tolerated and rarely required adjustment either for symptomatic hypotension or for changes in renal function.

All hospital admissions were recorded regardless of cause or precipitating factor. All hospital admissions occurring after referral were included as potentially due to heart failure or the alterations in heart failure therapy, but were compared only with the hospital admissions specifically for heart failure before referral. In general, hemodynamic monitoring was used only to adjust therapy and determine transplant candidacy at the time of referral and was not repeated during any rehospitalization unless it was necessary for the titration of inotropic therapy during the wait for urgent transplantation. Once the hemodynamic profile and responses were studied in an individual patient, all further therapy was usually guided by physical examination. Death and transplantation were also tracked as end points, with causes of death defined in accordance with a modified version of the American Heart Association's recommendations: sudden death defined as death occurring out of the hospital within 15 min of the onset of unexpected symptoms or during sleep (12). Follow-up ended September 1994, providing a minimum of 6 months for all surviving patients. At 6 months, the patients underwent detailed reassessment, with review of all hospital stays, determination of functional class and repeat cardiopulmonary exercise testing.

Costs. The costs attributed to the initial hospital stay after referral and for all subsequent hospital stays at the heart failure center were determined from the UCLA Medical Center computer accounting system, which incorporates cost averaging. The costs for hospital admissions occurring before referral and occurring at other hospitals after referral were estimated based on the published data and the costs of hospital stays at the UCLA Medical Center. In the absence of reliable information on the combined frequency of office visits to the heart failure center and in the community, no attempt was made to determine total outpatient costs. The proportion of time spent by the clinical nurse specialists on education and phone call follow-up for this group of patients was multiplied by their salary plus benefits for conversion into a dollar cost. Although visiting nurse participation was sought for patients at a considerable distance from the heart failure center or for those with limited in-house social support, the costs of their participation were not determined because multiple different networks were involved, the intensity of their involvement varied greatly and the duration was usually brief.

Statistical analysis. Changes in clinical variables within the group of patients were assessed by using unpaired t tests. Survival curves were calculated with the product limit (Kaplan-Meier) estimate using the BMDP statistical package (13). All analyses were performed in the entire group of discharged candidates, as well as in the subgroup of patients completing 6 months of follow-up without death or transplantation. To compare the ACE inhibitor doses before and after referral, the ACE inhibitor mean daily dose was converted to "captopril equivalents": 150 mg of captopril = 20 mg of enalapril or lisinopril or 40 mg of quinapril (14).

Results

Patient group at referral. During the study period, 392 patients were referred and considered appropriate for full evaluation for transplantation. Of these, 127 were rejected after evaluation because of contraindications and 29 were determined to be too well or to have a potentially reversible cause of cardiomyopathy. Of the remaining 236 accepted candidates, 22 (9.3%) could not be stabilized for hospital discharge and required urgent status transplantation during the initial hospital period, leaving 214 accepted candidates who were discharged. Baseline characteristics for the 214 study patients included LVEF of 0.21 and heart failure symptom duration of 18 months (all at least 6 months), as shown in Table 1. Peak oxygen uptake within 6 weeks of referral was 11.0 ml/kg per min. Angiotensin-converting enzyme inhibitors had been prescribed before referral in 165 patients (77%) at an average dose of 95-mg captopril equivalents (Table 2). The patient's referring physician was an internist or family physician in 12% of patients and a cardiologist in 87%.

In the 6 months before referral, 429 hospital admissions for heart failure occurred in the study group. Because hospital admissions during this period were not under prospective scrutiny, the prereferral hospitalization rate for subsequent comparison did not include an additional 62 hospital admissions attributed to other cardiac or noncardiac causes (29 for chest pain or myocardial infarction, 8 for infections, 6 for noncardiac surgery, 5 for bleeding, 12 for noncardiac causes and 2 unclear).

Table 1. Clinical Characteristics of Patients

Age (yr)	52 ± 10
Male gender	81%
Etiology	
Ischemic	48%
Idiopathic	43%
Other	9%
NYHA functional class	
III	44%
IV	56%
LVEF	0.21 ± 0.08
LVEDD (mm)	71 ± 15
Atrial fibrillation	18%
Serum sodium (mg/dl)	136 ± 10
Serum creatinine (mg/dl)	1.4 ± 0.6
Peak $\dot{V}O_2$ (ml/kg per min)	11.0 ± 3.6*

*n = 168. Data are presented as mean value ± SD or percent of patients. LVEDD = left ventricular end-diastolic dimension; LVEF = left ventricular ejection fraction; NYHA = New York Heart Association; $\dot{V}O_2$ = peak oxygen consumption during cardiopulmonary exercise testing.

Revision of therapy. Hemodynamic assessment at the time of evaluation for transplantation revealed increased right atrial, pulmonary artery and pulmonary wedge pressures; elevated systemic vascular resistance; and a depressed cardiac index (Table 3). During therapy with vasodilators and diuretic agents, pulmonary wedge pressure fell by 36%, right atrial pressure by 38% and systemic vascular resistance by 31% with the cardiac index increasing by 24% (all $p < 0.001$ compared with baseline). Average net diuresis was 4.2 ± 4.6 liters. Redesign of the medical regimen included initiation of an ACE inhibitor in an additional 18% of patients, for a total of 95% of patients on an ACE inhibitor. The mean daily dose in patients receiving ACE inhibitors at referral increased by 98% before discharge (Table 2).

Table 2. Medical Regimen

	Before Evaluation	After Evaluation	p Value
ACE inhibitor			
Captopril or equivalent	77%	95%	0.05
Daily dose	95 ± 120 mg	183 ± 143 mg	0.001
Isosorbide dinitrate	39%	76%	0.001
Hydralazine	10%	7%	
Furosemide	91%	97%	
Daily dose	48 ± 76 mg	90 ± 79 mg	0.01
Additional diuresis		4.2 ± 4.6 liters	
Digitalis	73%	87%	
Antiarrhythmic agents			
Type I	18%	1.4%	0.01
Amiodarone	12%	39%	0.01
Calcium channel blockers	28%	3%	0.01
Beta-blockers	2%	2%	
Coumadin	24%	36%	0.05

Data are presented as mean value ± SD or percent of patients. ACE = angiotensin-converting enzyme.

Table 3. Hemodynamic Response to Therapy

Hemodynamic Variable*	Initial	Final
Heart rate (beats/min)	89 ± 18	86 ± 16
MAP (mm Hg)	82 ± 18	72 ± 24
RAP (mm Hg)	11 ± 7	7 ± 4
PCWP (mm Hg)	24 ± 9	15 ± 7
Cardiac index (liters/min per m^2)	2.1 ± 1.1	2.6 ± 0.9
SVR (dynes·s·cm^{-5})	1,620 ± 680	1,120 ± 360

*All variables except heart rate changed significantly between baseline and after revision of therapy ($p < 0.0001$). Data are presented as mean value ± SD. MAP = mean arterial pressure; PCWP = pulmonary artery wedge pressure; RAP = right atrial pressure; SVR = systemic vascular resistance.

Clinical status at 6 months. During reassessment at 6 months, patients had significant improvement in subjective and objective indices of functional status. Functional class improved significantly for the 179 patients alive without transplantation at 6 months ($p < 0.001$) (Table 4), with 49% of patients classified as functional class I or II. The improvement remained significant ($p < 0.01$) when the 35 patients dying or undergoing transplantation were included and ranked as functional class IV for reassessment. Repeat cardiopulmonary exercise testing was available in 121 of the 168 patients with initial testing (72%), with increased oxygen consumption from 11.0 ± 3.6 to 15.2 ± 4.4 ml/kg per min ($p < 0.001$) and comparable improvement in anaerobic threshold (Fig. 1).

Subsequent hospital admissions. The improved functional status was reflected in the decreased hospital admission rate after referral. In the 6 months after discharge as transplant candidates, there were 63 hospital admissions (Fig. 2). Although only admissions attributed directly to heart failure were included from the prereferral period, all 63 hospital readmissions after referral were included as potentially related to heart failure program interventions. The 39 hospital admissions for volume overload and 11 for hypotension or worsening renal function were clearly due to heart failure, but also included were four admissions for arrhythmia, two for chest pain, two for infection, two for bleeding and three for noncardiac causes. During the 6 months, only 26% of the 214 patients required hospital admission, compared with 92% in the previous 6 months. Hospital readmission took place at the heart failure center in 49 (78%) of 63 patients.

The hospital admissions included the last hospital stay before transplantation for those 14 patients achieving urgent status at a mean follow-up of 3.2 months after initial assess-

Table 4. Functional Status Response to Therapy in 179 Patients

NYHA Functional Class	Before Management	6 mo After Management
I	—	26
II	—	61
III	79	78
IV	100	14

$p < 0.0001$ before versus 6 months after management. NYHA = New York Heart Association.
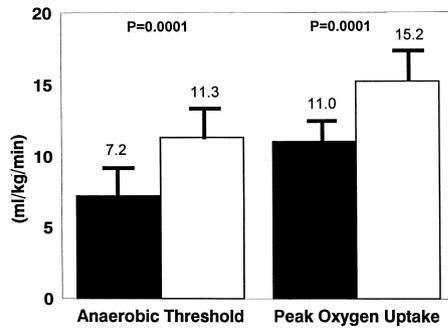
Figure 1. Impact of the management program on patient functional capacity. Peak oxygen consumption and anaerobic threshold (ml/kg per min) were measured during symptom-limited bicycle exercise using a 15-W ramp protocol. **Solid bars** = before management; **open bars** = after management.

ment. Elective outpatient transplantation was performed in 12 patients after a mean follow-up of 4.5 months. Of the nine deaths, six occurred suddenly, two were attributed to pump failure and one was noncardiac. The actuarial survival rate was 96% at 6 months, with 89% of patients without death or urgent transplantation.

Confining the analysis to only the 179 patients who completed 6 months of follow-up without transplantation yielded similar results, with 344 prereferral hospital admissions attributed to heart failure and 34 total hospital readmissions after evaluation—an 89% reduction. The 6-month hospital admission rate for these 179 patients declined from 1.9 ± 1.3 to 0.21 ± 0.48 (p < 0.0001). Freedom from hospital admission was 82.1% after initial evaluation compared with 9.5% in the preceding 6 months. If the hospital stay for transplant evaluation and revision of medical therapy is included in the postreferral period, there is still a significant reduction in the hospital admission rate, from 1.9 ± 1.3 to 1.2 ± 0.5 (p < 0.01).

Estimation of costs. The average cost of one rehospitalization at UCLA was $9,178 (range $2,890 to $38,930), comparable to estimates previously published by O'Connell and Bristow (2). The charges and costs could not be obtained from other hospitals, so the average UCLA cost was used to estimate the costs of the outside hospital readmission. For the whole group, the cost of hospital readmission after referral was estimated to be $578,000, compared with $3,937,000 before referral. Interestingly, the average cost of the initial elective hospital admission after referral for all 214 patients was $6,700 (excluding the specific laboratory and diagnostic tests required only for transplantation evaluation). This was lower than the cost for hospital readmissions, which were more likely to be in the intensive care unit than in the intermediate care unit.

When we consider the 179 patients who did not die or have a transplant during the next 6 months, the cost of hospital readmission after referral was $312,000, compared with $3,157,000 before referral. Even including the cost of hospital admission at referral for these patients ($6,050), the hospital cost for the 6-month period after referral was $1,396,000, compared with $3,157,000 before referral. For a heart failure nurse specialist carrying an active hospital and clinic case load of 100 to 200 patients with severe heart failure, the cost over the 6-month period was estimated to be in the range of $200 to $400 per patient.

Discussion

This study demonstrates that the clinical improvement after referral to a comprehensive heart failure management program translates into a major reduction in the hospital admission rate and thus the cost of heart failure for potential transplant candidates. The design of this study does not isolate
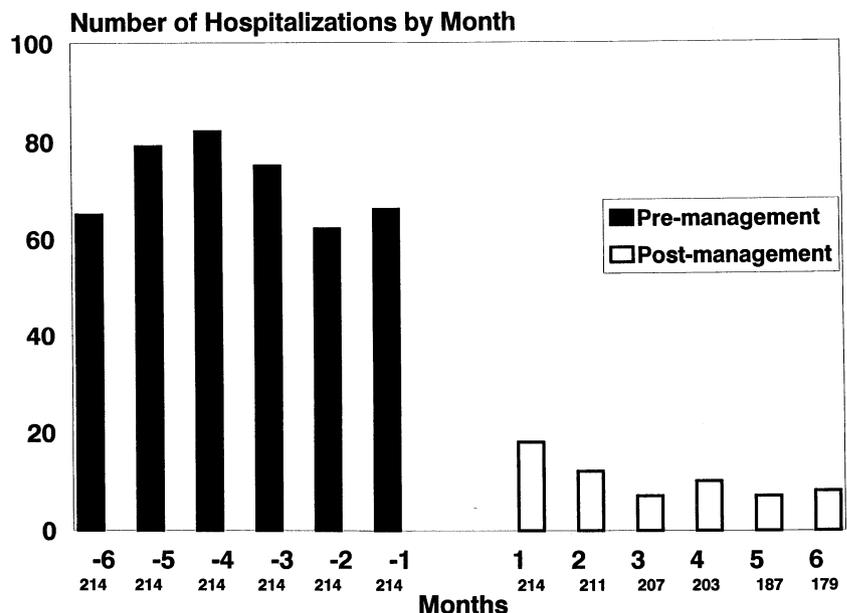

Figure 2. Distribution of hospital admissions for the 214 patients in the 6 months before and after comprehensive heart failure management. There were 429 hospital admissions for heart failure in the 6 months before referral and 63 hospital admissions in the 6 months after undergoing the management program (p = 0.0001). The **numbers beneath the months** indicate patients at risk for hospital admission during each interval.

the discrete contributions of many program components, each of which is provided at a relatively low marginal cost by major heart failure centers.

Heart failure program components. Therapies shown by major trials to be effective in heart failure have been underutilized outside of heart failure centers (15,16). The number of referred patients on ACE inhibitors was high in this urban referral population, but ACE inhibitors were also initiated successfully in 78% of the patients not on ACE inhibitors owing to various concerns before referral. In addition, the patients on ACE inhibitors had a 98% increase in average daily dose equivalents, which may have been a major component in clinical improvement (17–19). The program incorporated a flexible diuretic regimen that not only adjusts to changing dietary factors, but also empowers the patient to assess his or her condition, correlate diet with fluid retention and make decisions, thus restoring some sense of mastery over a frustrating chronic condition (20). There is limited information on the optimal dosing of diuretic drugs (21), which in this program were used to maintain a weight at which right- and left-sided filling pressures were close to normal during hemodynamic measurement at the time of evaluation. Further outpatient modifications of the diuretic regimen were made in the clinic with the specific goal of maintaining freedom from congestion, as assessed by orthopnea, edema or ascites and estimated jugular venous pressure elevation.

In addition to the flexible diuretic regimen, patients received detailed instructions regarding all of the patient education issues described in the Heart Failure Practice Guidelines (22). Vigilance of follow-up contact may have helped to decrease the rate of noncompliance, which has been described in 54% of patients with heart failure (23) and implicated in 53% of a group of elderly patients readmitted with heart failure (24). The impact of educational programs for improvement of compliance has been shown for heart failure (25) and other chronic illnesses (26).

Although exercise and other purposeful activity are routinely recommended in most heart failure programs, many patients had received specific instructions to avoid exercise and stress before referral. Lack of activity contributes to the deconditioning and sense of helplessness that often accompany advanced heart failure. In addition to improving one's attitude and feeling of self-worth, exercise has been shown to improve functional capacity and decrease symptoms (27). There may be additional long-term benefit resulting from improvement of autonomic balance (28). This program emphasized a self-supervised program of progressive walking, with reporting of frequency, duration and distance at each visit. Better access to local rehabilitation programs for more formal training may yield greater benefit, perhaps in conjunction with strength training.

It is not possible to isolate the specific benefit of a connection between the patient and heart failure team, contact that occurs on a regular basis rather than triggered only by symptoms of deterioration. It is not possible to identify which early interventions averted subsequent hospital admissions. In addi-

tion to receiving specific medication recommendations, patients may derive confidence from regular personal contact with a team dedicated to their chronic disease. Many patients perceive pessimism and frustration regarding this disease from overburdened practitioners caring primarily for healthier and less demanding patients.

Hospital readmission as an end point. Hospital readmission represents a useful outcome for analysis (18,29), reflecting both the frequency of clinical decompensation and the major component of cost for heart failure. Explicit process criteria have demonstrated hospital readmission rates to be influenced by the quality of care for heart failure (30,31). Although the specific circumstances of admission were not consistently reported, the major cause for hospital readmission is usually heart failure decompensation, both in this study and in others. The high hospital admission rates described in this group before referral reflect the severity of the patient's heart failure. In more general populations, hospital readmissions have been reported in 30% to 58% of patients during the next 3 to 6 months, with the higher rates seen in elderly patients (30–33).

Both the Studies of Left Ventricular Dysfunction trial of mild to moderate heart failure and the Cooperative North Scandinavian Enalapril Survival Study trial of severe heart failure showed a decrease in the hospital admission rate with ACE inhibitor therapy (18,19). In addition to specific interventions such as ACE inhibitor therapy and patient education, which have been shown to reduce hospital admission for heart failure, the impact of a multidisciplinary strategy was shown for a group of elderly patients with a mean LVEF of 0.43. The randomized study by Rich et al. (33) demonstrated a decrease in the 90-day readmission rate from 42% to 29%.

The high rates of hospital admission in patients with the most severe heart failure make this group a prime target for strategies to decrease hospital admissions and thus costs. This study showed an 85% decrease in the hospitalization rate in the 6 months after referral. Even if these initial admissions, frequently necessitated by clinical compromise under previous care, were attributed to the postreferral period, there is a 35% decrease in the rehospitalization rate. Despite including this initial hospital period at the time of referral as part of postreferral care, the cost was reduced by ~50%, from $3.2 million to $1.4 million, for the 179 patients alive without transplantation after 6 months.

The lower cost of the initial referral hospital period compared with urgent hospital admissions for decompensation bears emphasis because it is often assumed that heart failure therapy of this intensity is more expensive than other admission for heart failure. The lower cost reflects an economy of scale, an organized approach to optimization of therapy for discharge and the use of lower cost intermediate care units for hemodynamic monitoring.

There was no attempt made to calculate the cost of outpatient visits after referral, as they were shared in various ratios between the heart failure center and the referring physicians. It has been estimated that the direct cost of outpatient care for advanced heart failure is ~$4,200 per

patient per year regardless of where the patient is monitored (2). The use of routine laboratory evaluation is not included either, but is likely to be lower in the practice of heart failure specialists (34). Salaries plus benefits for the heart failure clinical nurses vary greatly between regions, with a standard case load of 100 to 150 patients in functional class III or IV heart failure, representing ~$200 to $400 per patient per 6-month period. No attempt was made to prorate salaries of administrative personnel per patient, but considerable time is required to coordinate communication between the heart failure team, referring physicians and visiting nurses. The involvement of the visiting nurses was variable, and the costs could not be ascertained. Consideration of all these program costs is dwarfed by comparison to the average cost of rehospitalizations, which was decreased by $15,900. Even when subtracting the initial hospital period after referral, there is a savings of over $9,000 per patient over 6 months. A major impediment to the integrated care of heart failure, however, remains the parallel existence of capitation and partial fee-for-service systems, within which the high costs of rehospitalization and the relatively low costs of a heart failure program are borne by different payors.

Study limitations. This study is limited by the retrospective collection of information before referral. Any incomplete recording, however, would only have decreased the apparent frequency of hospital admissions before referral and thus would have reduced the difference observed in the subsequent 6 months after referral.

The exact indications for hospital admission for heart failure are more often based on individual trends than on absolute criteria, although attempts to list the latter have been made (35). The reduction in the rehospitalization rate seen here may represent both clinical improvement and an altered threshold for admission, either of which could be considered to reflect heart failure program management.

The relation between costs and charges remains unclear in most hospital accounting systems. In addition, it is likely that the intensity and cost of each hospital stay is higher when there are fewer hospital admissions in a group of patients with heart failure. The costs determined here, however, are remarkably concordant with those reported elsewhere (2).

The exercise data are incomplete for 58 patients, so the conclusions regarding improvement in exercise tolerance may not be applicable to the entire group. For those 121 patients undergoing both studies, however, the parallel improvement in both peak oxygen consumption and anaerobic threshold suggests a true improvement in exercise capacity rather than an increased level of effort on the second test.

The lack of randomization makes it impossible to attribute all benefits seen to the interventions. The natural history has been grim, however. Previous randomized studies of patients in functional class III or IV heart failure receiving placebo in addition to conventional treatment with digoxin, diuretic agents and ACE inhibitors show progressive deterioration in functional status and high mortality (36–40). In the group of patients referred for transplantation, the highest rate of dete-

rioration and death occurs in the first 6 months after referral (38,39), which is the period this study is based on. Randomization to determine the impact of an experienced heart failure management program for this particular group of patients is ethically challenging, as this group represents apparent failures of the medical care previously provided to them. Any such randomization would have to take place before referral.

During this study, 14 patients underwent urgent transplantation and 9 patients died. Although the hospital readmission rate might have been higher if these patients had completed the 6 months, the rate of death and urgent transplantation over the 6 months is only 11%, which is very consistent with the observations in other transplant candidate groups (40).

This study focuses only on patients accepted for transplantation. These patients are younger and have fewer comorbid conditions, a better chance of compliance and better support systems than the much larger group of patients not eligible for transplantation. It is possible that the transplant candidates might demonstrate more benefit from a comprehensive heart failure management program than other patients. Most heart failure centers, however, have a tradition of commitment to provide care also to patients rejected for transplantation, and thus have extensive experience with comorbid conditions and patient noncompliance associated with this disease. For elderly patients with heart failure, the benefit of a specific program has already been demonstrated (33). It is possible that the very conditions that render patients less appropriate for transplantation might also render them less responsive to the medical care provided in the community and thus in greatest need of a focused management program.

Impact for heart failure management. The number of patients in functional class III or IV heart failure has been estimated to be between 400,000 and 800,000, accounting for almost 1,000,000 hospital admissions yearly. The average cost per hospital stay is $9,000, so half of this rate could represent up to a $4.5 billion reduction in costs.

As health care pathways become more narrow, the potential for heart transplantation is currently the only route by which most patients with heart failure can join an experienced heart failure program. Improved clinical status and decreased hospital admissions have been shown for this group. The next challenge is to define the impact that heart failure centers can have on the larger population with heart failure. Further study may eventually demonstrate that the persistence of functional class III or IV heart failure is a sufficient indication for referral to a heart failure center.

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