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Too early for cardiac transplantation — the right decision?

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In 109 out of 479 patients who were referred for cardiac transplantation it was considered to be too early to put them on the waiting list for a donor heart. The clinical course of these 109 patients was analysed in order to verify whether this decision had been right.

The mean age of the patients was 43 years, half of them suffered from ischaemic heart disease. The systolic left ventricular function of the patients was severely depressed (mean left ventricular ejection fraction 21%) and the left ventricular cavity was markedly dilated (mean echocardiographic end diastolic dimension 73 mm). Functional capacity, measured by bicycle ergometry, was low: mean maximal workload 62% of the expected load for gender, height and age.

The median follow-up duration was 31 months. The survival rate of the patients was better than that of 175 patients who were accepted for transplantation after referral, 92%, 87%, 81%, 71% and 73%, 73%, 71%, 68% after 1, 2, 3 and 4 years respectively. Re-assessment was necessary in 29% of the patients within 1 year and in 52% within 3 years. Twenty patients died: 12 patients died before re-assessment had been initiated (eight sudden deaths), six patients because of progressive heart failure before heart transplantation could be performed and two patients died after heart transplantation.

Left ventricular ejection fraction, pulmonary capillary wedge pressure and transpulmonary gradient were not reliable predictors of the course of the patients. In retrospect, a systolic blood pressure rise of less than 20 mmHg during exercise and an echocardiographic ventricular end-diastolic dimension of more than 75 mm helped in defining a subgroup of patients with an increased risk of clinical deterioration, who needed strict medical supervision after the decision to defer transplantation.

Introduction

Cardiac transplantation offers a normal life for a considerable number of years to patients who are severely incapacitated by end-stage heart disease. However, it remains difficult to determine the optimal moment to accept a patient onto the waiting list. The transplant team has to assess many patients ranging from very sick to moderately incapacitated. In each case three questions should be answered. First, is the current situation such that transplantation should be considered or can the decision be deferred? Second, can improvement of functional capacity and survival be expected from any therapy or procedure other than transplantation? And third, what are the expected benefits in terms of survival and quality of life from cardiac transplantation in this particular patient? Knowledge of potential reversibility of the underlying heart disease, of the effects of tailored medical therapy and of the results of the different types of conventional surgery is necessary to answer the first two questions. To answer the third question the expected survival and quality of life after cardiac transplantation must be weighed against the expected survival and quality of life with the underlying heart disease.

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In order to evaluate decision making after referral for heart transplantation during the first 5 years of our programme, we reviewed the clinical course of those patients who were referred for transplantation, but in whom we expected that the clinical course would remain stable for some time, such that transplantation could be postponed. We report survival and the need for re-assessment of the initial decision in these patients. Special attention is paid to factors that can easily be determined and may help to predict a possible fatality and the need for re-assessment, despite a presumed benign clinical course.

Patients and methods

Between June 1984 and July 1990, 479 patients were referred to one of the three hospitals which participate in the Thoraxcentre Heart Transplant programme, the University Hospitals of Rotterdam and Leiden and the St Antonius Hospital in Nieuwegein. The patients were divided into six groups: patients still under evaluation, patients who died during assessment, patients 'too early to put on the waiting list', patients in whom conventional surgery was recommended, patients with contraindications for transplantation (initially an age beyond 55 years was considered to be a contraindication) and patients accepted on the waiting list for transplantation.

The decisions were based on assessment of the patients by cardiologists of the transplant team and/or on written information from the referring physicians. Criteria used

to decide that a patient was not (yet) suffering from end-stage heart disease and that it was therefore 'too early to put him on the waiting list' despite severely depressed left ventricular function, included a stable clinical course without the need for hospital admissions for at least three months, absence of dyspnoea at rest, absence of fluid retention and/or hyponatremia on oral medication and the ability to tend oneself. Evaluation in the heart failure clinic included physical examination, electrocardiogram, chest X-ray, complete blood count, serum electrolyte determinations, serum urea nitrogen and creatinine, liver function tests, glucose levels, 2-dimensional-echocardiography and exercise testing. Neuro-hormone levels were not determined on a routine basis. In most cases left ventricular ejection fraction (measured by nuclear or contrast angiography) and coronary anatomy were already known before referral to the clinic. Recent haemodynamic data from right heart catheterization were available in some of the patients only.

Functional capacity was determined by upright bicycle ergometry with workload increments of 10 W . min^{-1}. Pedalling speed was 60 revolutions . min^{-1}. Workload was expressed as a percentage of the expected maximal load for gender, age and height. Heart rate, rhythm, QRS configuration and ST-changes were monitored continuously. Blood-pressure was measured by armcuff, at rest, every 2 min during exercise at the highest workload and every 2 min during the recovery period. Subjective symptoms such as intractable fatigue, dyspnoea, dizziness and angina pectoris, or objective signs such as increasing ventricular tachy-arrhythmias or a drop in systolic blood-pressure caused the test to be stopped. Gas exchange measurements were performed in a few patients only and have not been included in this report.

The initial data of all patients who were referred for cardiac transplantation were stored in a computer database. Follow-up data were obtained from visits to the outpatient heart failure clinic and from written information from the referring cardiologists.

Group data were expressed as means $\pm$ SD. Analysis of the 95% confidence intervals of the differences between the means was used to compare survival proportions of the patient groups (Kaplan-Meier method) and of patient characteristics.

Results

Of the 479 patients who were referred for heart transplantation, 28 were still under evaluation on 1 August 1990. Of the remaining 451 patients, 51 died before assessment had been completed. In 32 patients other surgical procedures were recommended and 175 patients were accepted on the waiting list for transplantation. The median waiting time until transplantation between the end of 1986 and December 1990 increased from 52 to 147 days for patients waiting at home in a stable condition and from 8 to 30 days for patients waiting in hospital, dependent on intravenous catecholamines or intra-aortic balloon pump support. Contraindications for transplantation were present in 84 cases and in 105 cases we considered it to be too early to put the patient on the waiting list. In another four patients transplantation was recommended initially but this advice was withdrawn after clinical improvement and stabilization with oral medication. These 109 patients are described in this report.

Table 1 Baseline characteristics of 109 patients in whom it was considered to be too early for cardiac transplantation

Age (years)	43 $\pm$ 11
Gender	
Male	89
Female	20
Heart disease	
Cardiomyopathy	52
Ischaemic heart disease	51
Valvular heart disease	3
Other	3
Medication prior to referral	
Digoxine	105
Diuretics	105
ACE inhibitors	84
Antiarrhythmic agents	2
Catecholamines i.v.	6
Phosphodiesterase inhibitors	0
Left ventricular ejection fraction (%)	21 $\pm$ 11
LV end-diastolic dimension (echo . mm^{-1})	73 $\pm$ 13

ACE inhibitors = angiotensin-converting enzyme inhibitors.

All patients had been hospitalized at least once for treatment of severe congestive symptoms but were in New York Heart Association class II or III at the time of referral. Baseline characteristics of the patients are presented in Table 1. The age-range of 11 to 57 years is explained by our initial policy to exclude young children and patients over 55 years from cardiac transplantation. Dilated cardiomyopathy was the underlying heart disease in half of the patients. All patients, except four, had been treated with digoxine and diuretics and, in addition to these medications, angiotensin-converting enzyme inhibitors were used by 77% of the patients. Only six patients had been treated with intravenous catecholamines before referral. A marked dilatation of the left ventricle (mean echocardiographic end-diastolic dimension 73 mm) was found, as was a severely depressed systolic function (mean left ventricular ejection fraction 21%). Functional capacity was limited by dyspnoea and fatigue in all but three patients. In the latter patients angina pectoris was the main complaint.

Exercise testing was performed in 75 patients. The maximal workload at bicycle ergometry was 62 $\pm$ 18%. Systolic blood pressure at rest was 114 $\pm$ 15 mmHg and increased by 26 $\pm$ 19 mmHg on average during exercise. Heart rate at rest was 97 $\pm$ 17 beats . min^{-1} and increased by 50 $\pm$ 25 beats . min^{-1} during the test. In 38 patients recent invasive haemodynamic data were already available or were collected during the initial evaluation. Pulmonary capillary wedge pressure was 23 $\pm$ 7 mmHg. Mean pulmonary artery pressure was 32 $\pm$ 11 mmHg

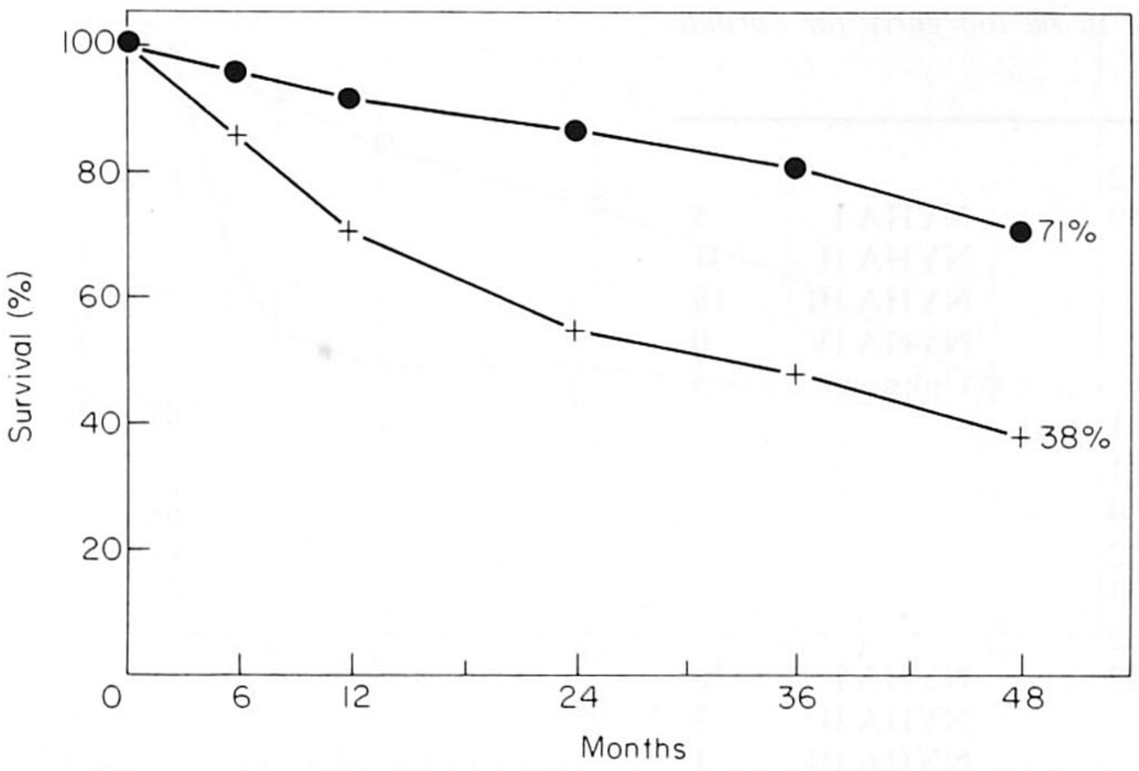

Figure 1 Survival of the 109 patients who were not, as yet, considered to be candidates for transplantation. The upper curve represents overall survival including the outcome of the change of policy. The lower curve represents 'event free' or rather 're-assessment-free' survival. ● = overall survival, + = survival without re-assessment.

and right atrial pressure was 10 ± 7 mmHg. These data confirm the presence of heart failure in this group of patients.

The survival rates of the 109 patients were 92%, 87%, 81% and 71% at 1, 2, 3 and 4 years respectively (Fig. 1). The clinical course of 71 patients in whom no change of the initial policy, 'too well for transplantation', was made is described in Table 2. Fifty-nine patients are alive, 37 of whom are in functional class I or II. During follow-up 38 patients were re-assessed 2–40 (median 9) months after the initial decision, while 71% of the patients survived without re-assessment for at least 12 months after the initial evaluation (Fig. 1). In 35 patients heart transplantation was reconsidered and 22 out of 24 patients who received a donor heart are alive. In three patients conventional surgery was recommended and successfully performed. Duration of follow-up for the whole group ranged from 3 to 67 (median 31) months with a larger proportion of patients with a follow-up duration of more than 4 years in the group without change in policy (Table 3).

There were no differences in age (44 *vs* 42 years), distribution of gender (males 76% *vs* females 86%) and underlying heart disease (cardiomyopathy 46% *vs* 50%) between the patients who survived without re-assessment and the group of patients who died or were re-evaluated. The percentage of patients who used angiotensin-converting enzyme inhibitors at referral was lower in the group of patients who survived without re-assessment (66% *vs* 96%; 95%CI of the difference is 14–45). The haemodynamic parameters and the results of exercise testing show considerable overlap (Table 4). Nevertheless left ventricular end-diastolic diameter was larger and systolic blood pressure at rest was lower in patients who needed re-assessment or those who died. Furthermore, 59% of the patients who showed a 20 mmHg blood pressure rise or more during exercise survived without re-assessment in contrast to 35% of the patients with a less than 20 mmHg blood pressure rise (Table 4).

A total of 20 patients died, 12 in the group of patients in whom no change in policy was considered necessary and eight in the group of patients in whom re-assessment took place. In the first group eight deaths were sudden and three were due to progressive pump failure while one patient died from unknown causes after an episode of congestive heart failure. In the second group four deaths were caused by rapidly progressive heart failure and in two patients death occurred suddenly. A 53-year-old man with ischaemic heart disease and a LVEF of 5% suffered sudden death at home shortly after calling attention to a mild increase in dyspnoea. A 22-year-old man with dilated cardiomyopathy died because of ventricular tachycardia deteriorating into ventricular fibrillation after admission to the hospital because of pneumonia. Survival rates at 6 months, 2 and 4 years in the groups with and without change in policy did not differ significantly: 97%, 86%, 70% and 97%, 88%, 73% respectively. Although survival after transplantation at our centre was excellent, 91% and 89% at 1 and 3 years, the survival of the patients reported here appeared to be better than the survival of the 175 patients who had been accepted on the waiting list for transplantation at the initial evaluation (Fig. 2). This is caused by the fact that, although only 13 patients died after transplantation, 34 patients died 'on the waiting list', before transplantation could be performed.

Discussion

The goal of this study was to verify whether the decision, 'too early to put this patient on the waiting list for transplantation' had been right. It would be wrong to withhold cardiac transplantation when really needed but equally wrong to use scarce donor hearts for patients who could be expected to live acceptable lives with their own hearts for a reasonable period of time. Therefore we analysed survival and need for re-assessment in 109 patients whom we considered 'not yet' candidates for cardiac transplantation at the time of referral.

Survival of these patients was better than that of the patients who were accepted on the waiting list for transplantation after referral. However, re-assessment, leading to a change of policy, appeared necessary in one third of the patients within 1 year and in half of the patients within 3 years. The excellent survival rate is, without any doubt, caused by the timely reconsideration of the policy and the ultimate advice to operate (although 11% of the patients died suddenly before re-assessment could be considered). Survival of patients who remained on medical therapy was better than in most studies of patients who were referred to other centres because of intractable heart failure, before the introduction of angiotensin-converting enzyme inhibitors[1–3]. The survival of the patients was also better than the 46% 1-year survival rate of cardiomyopathy patients with left ventricular ejection fractions below 25%, considered too well for transplantation in an earlier report[4]. This may be due in part to the fact that during the first 2 years of the programme many patients

Table 2 Clinical course in 109 patients in whom it was considered to be too early for cardiac transplantation (1 August 1990)

No change in policy ($N=71$)	Died	12		
	Alive	59	NYHA I	5
			NYHA II	31
			NYHA III	18
			NYHA IV	0
			Unknown	5
Re-assessment	Refused HTX (alive)	1		
	Contraindication HTX (alive)	1		
	Died during re-assessment	4		
	Died on waiting list	2		
	Alive on waiting list	3		
	Died after transplantation	2		
	Alive after transplantation	22	NYHA I	18
			NYHA II	3
			NYHA III	1
Other surgery		3	NYHA I	2
			NYHA II	1

HTX = heart transplantation, NYHA = New York Heart Association classification.

Table 3 Comparison of follow-up duration in the patients in whom there was no change in policy and the patients who were re-assessed

Months	No change $N=71$	Re-assessed $N=38$
0–6	9 (13%)	3 (8%)
7–12	12 (17%)	8 (21%)
13–24	10 (14%)	9 (24%)
25–36	16 (22%)	12 (31%)
37–48	14 (19%)	6 (16%)
49–60	9 (13%)	0 (0%)*
>60	1 (1%)	0 (0%)

*95% Confidence Interval for the difference = 5–20%.

Table 4 Comparison of the distribution of parameters of functional capacity and haemodynamics at referral

		N	† or re-assessment	
LVEF	>20%	31	48%	NS
	≤20%	53	59%	
PCW	<20 mmHg	11	45%	NS
	≥20 mmHg	25	56%	
TPG	<15 mmHg	31	52%	NS
	≥15 mmHg	7	14%	
RA	≤8 mmHg	12	33%	NS
	>8 mmHg	12	41%	
△ BP	≥20 mmHg	14	41%	*
	<20 mmHg	29	65%	
LVED	≤75 mm	33	33%	†
	>75 mm	24	74%	

*95% Confidence interval of the difference: 0–47 ($P<0{\cdot}05$).
†95% Confidence interval of the difference: 14–67 ($P<0{\cdot}005$).
LVEF = left ventricular ejection fraction, PCW = pulmonary capillary wedge pressure, TPG = transpulmonary gradient (mean pulmonary artery pressure minus mean capillary wedge pressure), RA = right atrial pressure, △ BP = change in systolic blood pressure during exercise, LVED = left ventricular end-diastolic diameter (echo), N = survivors without reassessment; † = died.
NS = not significant.

were referred too early on the mere finding of severely impaired left ventricular function without allowance for adaptation mechanisms which may compensate for the failing pump. In the first two years of our programme the percentage of patients accepted on the waiting list after referral was only 10%, in contrast to 45% in 1989 and 1990.

The fraction of patients who died suddenly without re-assessment is in accordance with earlier reports indicating that 30 to 60% of deaths in heart failure patients are sudden[5–7]. Arrhythmias were the most probable cause of death in these patients but, as in the patients who were re-assessed, changes in the degree of heart failure may have contributed to the death of these patients. Although reports on the predictive value of ventricular arrhythmias on the prognosis in heart failure are contradictory[8–10], we recommend 24 h continuous ECG-recording and to repeat this investigation after tailoring of heart failure medication in all patients referred for heart transplantation. Furthermore, we instruct the patients to pay special attention to minor signs of heart failure and to warn their physician at short notice if changes occur, such as a gain in weight, upper abdominal discomfort or the need for an extra pillow during the night.

For six of the 38 patients, in whom the initial decision to defer transplantation was reconsidered, this change of policy came too late. Symptoms of severe heart failure made hospital admission necessary. Five of the patients died either during evaluation or while waiting for a donor heart. Such deaths may be avoided by earlier recognition of progression of heart failure by the patient and the

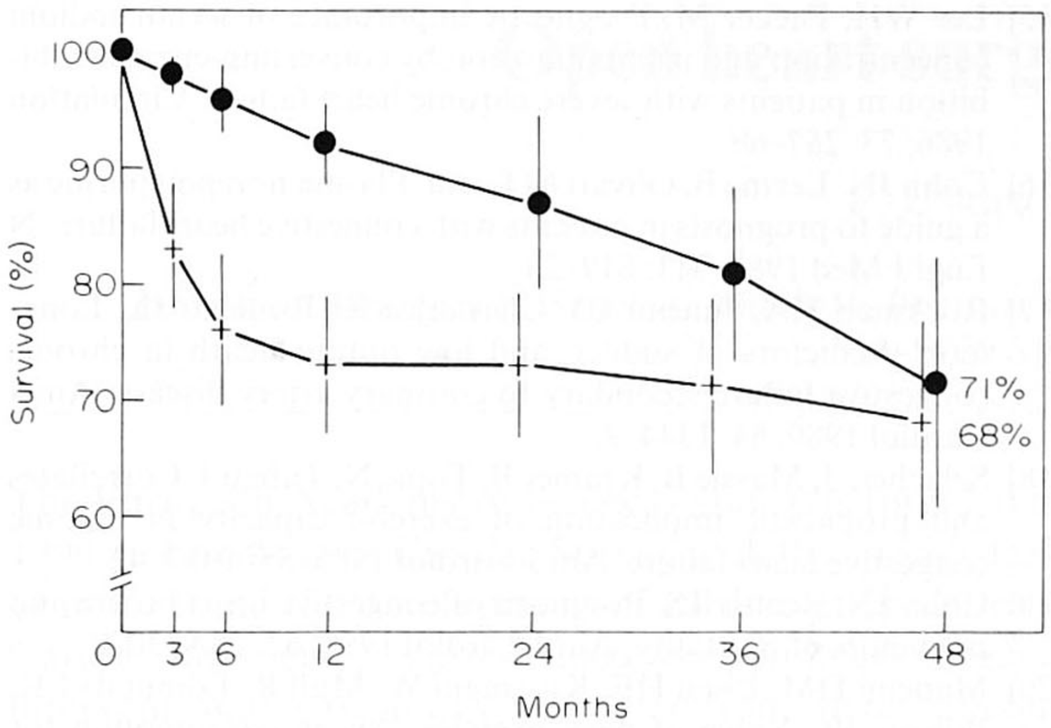

Figure 2 The survival of patients considered to be not yet candidates for cardiac transplantation compared to the survival of patients accepted for transplantation. Both curves start at the time of initial referral. ● = Too well for heart transplantation, + = accepted for heart transplantation. Vertical bars represent the 95% Confidence Interval.

referring physician resulting in rapid referral to the transplant centre.

Several other studies have analysed predictors of mortality in patients with heart failure and reported a poor prognosis in patients with low left ventricular ejection fraction, ventricular arrhythmias, high filling pressures, high transpulmonary gradient, hyponatraemia and high plasma norepinephrine levels[4,7,11–19]. In practice, however, these parameters prove to be of little help in decision making in ambulatory patients. In an attempt to predict which patients would remain stable, we compared the available data in two groups of patients: those who survived without re-assessment and those who died or in whom the initial policy was revised. This analysis was retrospective and its value is limited by missing data from some of the patients. Nevertheless, the analysis confirms that, in patients with severely impaired left ventricular function, left ventricular ejection fraction, pulmonary capillary wedge pressure, transpulmonary gradient and right atrial pressure are not reliable indicators of the future course of the disease. In earlier reports indicating the value of these measurements, more patients with only moderate ventricular impairment were included which may explain this apparent discrepancy. Although the predictive value of exercise testing in this setting was unknown until Mancini's recent report (published after the completion of this study) we used bicycle ergometry as an objective measure for functional capacity[1,18–20].

It appeared that mortality or the need for re-assessment were lower in patients who showed a 20 mmHg or greater rise in systolic blood pressure during exercise indicating residual functional reserve of the left ventricle. In patients with less than a 20 mmHg blood pressure rise during exercise mortality or the need for re-assessment was 50%. Furthermore, re-evaluation was needed less frequently in patients with moderately enlarged ventricles on echocardiography.

Instability of symptoms, frequent hospital admissions and the need for intravenous administration of catecholamines have been recognized as predictors of a worse outcome at short notice, especially in patients accepted for transplantation[21]. This was confirmed in the patients in whom initially transplantation seemed to be, as yet, unwarranted, since the patients' condition often deteriorated rapidly after progression of heart failure.

From our initial experience it is concluded that the decision to defer transplantation was justified in most of these patients. However, revision of this decision was needed frequently. Thus, it is recommended that such patients are instructed to watch for minor signs of worsening. Patients should be kept under strict medical supervision to enable immediate referral to the transplant centre if progression of heart failure occurs. The degree of rise in systolic blood pressure during exercise and the echocardiographic dimension of the left ventricle may help to define the group of patients who need close observation.

An additional conclusion may be that reporting of the results after cardiac transplantation on the principle 'intention to treat' illustrates the impact of this procedure on the survival of patients with heart failure more accurately than the methods used until now.

Future research should be directed towards the prevention of sudden death in patients with heart failure. Persistence of recurrent ventricular tachycardias or ventricular fibrillation despite optimal medical therapy may become an indication for urgent transplantation because of an increased risk of sudden death[4], while antiarrhythmic therapy may further increase pump failure without decreasing the risk. One may speculate about the need for electrophysiological testing or implantation of an automatic internal cardioverter defibrillator, not only in patients with refractory symptomatic sustained ventricular tachycardias or ventricular fibrillation, but also in patients with non-sustained ventricular arrhythmias who are otherwise 'too well' for cardiac transplantation[22]. The limited availability of donor hearts and financial resources, however, means the search for methods for the identification of those patients who will benefit from these procedures is necessary. Signal-average electrocardiograms may provide such a method by showing late potentials. Although its usefulness appears to be limited to cases of advanced heart failure, a prospective study in stable patients being treated with tailored medical therapy may contribute to the solution of the problem[23].

References

[1] Wilson JR, Schwartz JS, St John Sutton M *et al.* Prognosis in severe heart failure: relation to hemodynamic measurements and ventricular ectopic activity. J Am Coll Cardiol 1983; 2: 403–10.

[2] Massie BM, Ports T, Chatterjee K *et al.* Longterm vasodilator therapy for heart failure: clinical response and its relationship to hemodynamic measurements. Circulation 1981; 63: 269–78.

[3] Cohn JN, Archibald DG, Ziesche S *et al.* Effect of vasodilator therapy on mortality in chronic congestive heart failure. N Engl J Med 1986; 314: 1547–52.

[4] Warner Stevenson L, Fowler MB, Schroeder JS, Stevenson WG, Dracup KA, Fond V. Poor survival of patients with idiopathic cardiomyopathy considered too well for transplantation. Am J Med 1987, 83: 871–6.

[5] Hofman T, Meinertz T, Kasper W *et al.* Mode of death in idiopathic dilated cardiomyopathy: a multivariate analysis of prognostic determinants. Am Heart J 1988; 166: 1455.
[6] Packer M. Sudden unexpected death in patients with congestive heart failure: a second frontier. Circulation 1985; 72: 681–5.
[7] Likoff MJ, Chandler SL, Kay HR. Clinical determinants of mortality in chronic congestive heart failure secondary to idiopathic dilated or ischemic cardiomyopathy. Am J Cardiol 1987; 59: 634–8.
[8] Huang SK, Messer JV, Denes P. Significance of ventricular tachycardia in idiopathic dilated cardiomyopathy: observations in 35 patients. Am J Cardiol 1983; 51: 507–12.
[9] Von Olshausen K, Schafter A, Mehmel HC, Schwartz F, Senges J, Kubler W. Ventricular arrhythmias in idiopathic dilated cardiomyopathy. Br Heart J 1984; 51: 195–201.
[10] Meinertz T, Hofman F, Kasper W *et al.* Significance of ventricular arrhythmias in idiopathic dilated cardiomyopathy. Am J Cardiol 1984; 53: 902–7.
[11] Warner Stevensen L, Dracup KA, Tillisch JH. Efficacy of medical therapy tailored for severe congestive heart failure in patients transferred for urgent cardiac transplantation. Am J Cardiol 1989; 63: 461–4.
[12] Unverferth DV, Magorien RD, Moeschberger ML, Baker PB, Fetters JK, Leier CV. Factors influencing the one-year mortality of dilated cardiomyopathy. Am J Cardiol 1984; 54: 147–52.
[13] Franciosa JA. Why patients with heart failure die: hyemodynamic and functional determinants of survival. Circulation 1987; 75: (Suppl. IV) 20.
[14] Keogh AM, Freund J, Baron JW, Hickie JB. Timing of cardiac transplantation in idiopathic cardiomyopathy. Am J Cardiol 1988; 61: 418–22.
[15] Lee WH, Packer M. Prognostic importance of serum sodium concentration and its modification by converting-enzyme inhibition in patients with severe chronic heart failure. Circulation 1986; 73: 257–69.
[16] Cohn JN, Levine B, Olivari MT *et al.* Plasma norepinephrine as a guide to prognosis in patients with congestive heart failure. N Engl J Med 1984; 311: 819–23.
[17] Rockman HA, Juneau CJ, Chatterjee K, Rouleau JL. Long-term predictors of sudden and low output death in chronic congestive failure secondary to coronary artery disease. Am J Cardiol 1989; 64: 1344–8.
[18] Szlachcic J, Massie B, Kramer B, Topic N, Tubau J. Correllates and prognostic implication of exercise capacity in chronic congestive heart failure. Am J Cardiol 1985; 55: 1037–42.
[19] Cohn JN, Rector TS. Prognosis of congestive heart failure and predictors of mortality. Am J Cardiol 1988; 62: 25A–30A.
[20] Mancini DM, Eisen HE, Kussmaul W, Mull R, Edmunds LR, Wilson JR. Value of peak exercise oxygen consumption for optimal timing of cardiac transplantation in ambulatory patients with heart failure. Circulation 1991; 83: 778–86.
[21] Massie BM, Conway M. Survival of patients with congestive heart failure: past, present, and future prospects. Circulation 1987; 75 (Suppl IV) 11.
[22] Bolling SF, Deeb GM, Morady F *et al.* Automatic Internal Cardioverter Defibrillator: a bridge to heart transplantation. J Heart Lung Transplant 1991; 10: 562–6.
[23] Middlekauff HR, Stevenson WG, Woo MA, Moser DK, Stevenson LW. Comparison of frequency of late potentials in idiopathic dilated cardiomyopathy and ischemic cardiomyopathy with advanced congestive heart failure and their usefulness in predicting sudden death. Am J cardiol 1990; 66: 1113–7.