

Table 5 Determinants of mortality in heart failure

Determinant	Lee (1986) ¹⁴	Middlekauff (1991) ¹³	Parameshwar (1992) ¹⁵ †	Scrutinio (1994) ⁵	Chin (1997) ¹	Aaronson (1997) ⁷	Cowie (2000) ²	Zugck (2001) ⁶	Jiang (2001) ⁸	Present study
Age	+	NR	0	0	0	0	+	NR	+	0
Depression	NR	NR	NR	NR	NR	NR	NR	NR	+	NR
Crepitations	NR	NR	NR	NR	NR	NR	+	NR	NR	NR
Heart rate	0	NR	NR	NR	NR	+	0	+	NR	0
Intraventricular conduction delay	NR	NR	NR	NR	NR	+	NR	+	NR	NR
Non-sinus rhythm	NR	+	NR	NR	+	0	0	NR	NR	0
Lower LVEF	+	+	+	+	NR	+	0	+	0	NR
Lower serum sodium	+	+	+	NR	0	+	0	+	NR	0
Higher serum bilirubin	+	NR	NR	NR	NR	NR	NR	NR	NR	NR
Lower (systolic) blood pressure	NR	NR	NR	NR	+	+	+	NR	NR	+
Higher mean arterial pressure	0	+	NR	NR	NR	+	NR	+	NR	NR
Myocardial infarction or ischaemia	NR	+	0	+	0	+	0	+	+	0
Higher NYHA class	NR	NR	NR	+	NR	0	0	NR	+	+
Lower peak oxygen uptake	NR	NR	+	0	NR	+	NR	+	NR	NR
Six minute walking test	NR	NR	NR	NR	NR	NR	NR	+	NR	NR
Impaired renal function	+	NR	0	NR	0	0	+	NR	NR	+
Systolic dysfunction	NR	NR	NR	NR	NR	NR	0	NR	NR	NR
Diabetes	NR	NR	NR	NR	+	0	NR	NR	NR	+
Lower body weight or BMI	NR	NR	NR	NR	NR	0	NR	NR	NR	+
Ankle oedema	NR	NR	NR	NR	NR	NR	0	NR	NR	+
Absence of use of β blockers	NR	NR	NR	NR	NR	NR	NR	NR	NR	+

+, Associated with higher mortality in multivariate analysis; 0, no association in multivariate analysis; NR, not reported.

†Combined end point of death or transplantation.

BMI, body mass index; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

weighing 70 kg, with a history of renal insufficiency, diabetes, ankle oedema, and a blood pressure of 130/80 and who does not use a β blocker receives a score of $(60/17 + 9 + 17 + 10 - 70/3 + 13) = 29.2$. In our data, the score ranged from -32.2 to $+31.7$ (mean -0.3 , median 0.5) and the AUC of the rule was 0.80 (95% confidence interval 0.72 to 0.88).

Table 4 shows the incidence of mortality in our patients across different score categories. From this table one can directly obtain the observed mortality per score category (reading horizontally). For example, of 25 subjects with a score of ≥ 7 , 78% ($n = 18$) died, while only 12% ($n = 3$) of the 25 subjects with a score of < -15 died. Similarly, the positive and negative predictive values for various cut off points can be calculated: the positive predictive value for a score ≥ 7 is $31/48 = 65\%$, while the negative predictive value of a score < 7 is $84/104 = 81\%$. Reading the table vertically provides estimates of the sensitivity and specificity at different thresholds. For example, 74 ($26 + 25 + 23$) subjects received a score of ≥ 1 . Of these, 43 ($12 + 13 + 18$) indeed died, correctly predicting 84% of all deaths (that is, the sensitivity or true positive rate). As 31 (31%) of all subjects predicted as future deaths did not die, the specificity of a threshold of 1 was $100 - 31\% = 69\%$.

DISCUSSION

This study shows that a combination of easily obtainable variables accurately predicts 18 months mortality in patients with heart failure. Except for the use of β blockers, weight, and quality of life score, these predictors were also used in earlier studies (table 5).

Several studies have used multivariate logistic regression to derive predictive models.^{1 2 5-7 13-15} Most of these studies, however, involved highly selected and mostly relatively young patient populations (for example, patients referred for cardiac transplantation). Our study was undertaken in patients included in a randomised controlled trial. Although there were few inclusion or exclusion criteria in this trial, patients with severe psychiatric problems or dementia, those with a planned admission to a nursing home, those who did not manage their own drug treatment, and those with a life expectancy of less than three months (in the opinion of their physician) were

excluded. The exclusion of patients with a short life expectancy mainly led to the exclusion of those with malignancies and other comorbidities, but not to the exclusion of those with moderate or severe heart failure. It should be borne in mind that these patients were in a clinical trial designed to improve compliance. Patients had to give their informed consent and this is likely to have led to the selection of a group of relatively motivated patients. However, it is not plausible that this would have influenced the predictive value of objective parameters such as the presence of diabetes or renal dysfunction.

Other studies have often included variables that are not widely available in heart failure patients. The determinants included in our study, however, are usually routinely available and they turned out to be at least as predictive of mortality as those more specialised variables included in other studies.^{6 7} Our predictive values were comparable with those in a recent study in which age, the presence of pulmonary crepitations, a lower systolic blood pressure, and higher creatinine concentrations were most predictive of mortality.² That study, however, did not report the prognostic value of diabetes, which was an important predictor in our study as well as in another study.¹

Although results of echocardiography (95%), chest radiography (87%), and electrocardiography (99%) were available in most of our cohort, more specific information on these data, such as ejection fraction (54%) and diastolic function (35%), were only available in a proportion of the participants and were subject to large intrahospital differences. These findings were therefore not included in the analyses.

Finally, although other studies have composed logistic regression models, they did not assess the prognostic performance of a scoring rule combining the individual predictors derived from the model. Although there is no consensus on sample size estimations in studies deriving multivariable prognostic models, as a rule of thumb several investigators recommend 10 or more events per variable to allow a robust estimation of the coefficients.¹⁶ As we included more variables in our models, the precision of some of our estimates may be limited. However, limitation of our analyses to the seven determinants most likely to influence prognosis,