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Compliance with non-pharmacological recommendations and outcome in heart failure patients

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Aims The aim of this prospective study was to investigate the association between compliance with non-pharmacological recommendations (diet, fluid restriction, weighing, exercise) and outcome in patients with heart failure (HF).

Methods and results In total 830 patients after an HF hospitalization participated in the study (age 70 ± 11; left ventricular ejection fraction 34%). Compliance was measured 1 month after discharge; patients were followed for 18 months. Primary outcomes were the composite of death or HF readmission and the number of unfavourable days. Cox regression analysis was used to determine the association between primary outcome and compliance. Adjustments were made for those variables that were identified as confounders in the association between compliance and outcome. Patients who were non-compliant with at least one of the recommendations had a higher risk of mortality or HF readmission (HR 1.40; $P = 0.01$). Non-compliance with exercise was associated with an increased risk for mortality or HF readmission (HR 1.48; $P < 0.01$), while non-compliance with daily weighing was associated with an increased risk of mortality (HR 1.57; $P = 0.02$). Non-compliance (overall) and non-compliance with exercise were both associated with a higher risk for HF readmission [HR 1.38; $P < 0.05$(overall) and HR 1.55; $P < 0.01$(exercise)]. Patients who were overall non-compliant or with weighing and exercise had more unfavourable days than compliant patients.

Conclusion Non-compliance with non-pharmacological recommendations in HF patients is associated with adverse outcome.

Keywords Adherence • Compliance • Non-pharmacological treatment • Heart failure • Outcome

Introduction

Although heart failure (HF) still has a poor outcome,[1] prognosis has improved considerably in the last decades by the achievements in pharmacological and non-pharmacological treatment. According to current HF guidelines, multiple medications should be prescribed to HF patients.[2,3] In addition, patients should follow a low sodium diet, restrict the amount of fluid, weigh themselves daily, follow recommendations on exercise, and contact a healthcare provider in case of worsening symptoms. Although these measures are important, such a complex regimen may be rather difficult for these, often elderly patients, leading to a reduced compliance to one or more of the components of the regimen.[4,5]

Compliance can be defined as the extent to which a patients' behaviour—in terms of taking medication, following diet or executing other lifestyle recommendations—coincides with (agreed) recommendations from a healthcare provider.[4] Compliance with both medication and non-pharmacological treatment has been reported to be poor in HF patients. The lowest compliance with medication was 10%, however, most studies describe compliance rates of ~70%.[5] Compliance with daily weighing ranged from 12 to 75% and compliance with exercise from 41 to 58%.[5]

Several recent studies have shown that non-compliance with medication in patients with HF is associated with a poor prognosis.[6,7] Regarding compliance with non-pharmacological recommendations, however, only very few data are available on the association with

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outcome. This is remarkable, since in everyday clinical practice, these recommendations are often prescribed for HF patients. Results from observational and retrospective studies have suggested that non-compliance with treatment, including non-compliance with sodium-restricted diet, may contribute to worsening HF, sometimes leading to readmission.[8,9] However, until now there are no prospective studies describing the relationship between compliance with non-pharmacological treatment and clinical outcome.

The aim of the present study therefore was to analyse the relationship between compliance with non-pharmacological recommendations (sodium-restricted diet, fluid restriction, daily weighing, and exercise) and mortality and readmission for HF. Accordingly, we studied a large population of HF patients in which this was prospectively investigated.

Methods

Patients in the present study were enrolled in the COACH study (Coordinating study evaluating Outcomes of Advising and Counselling in Heart failure). COACH was a randomized multi-centre trial in the Netherlands in which 17 hospitals participated. Patients were included in COACH between October 2002 and February 2005 after they had been hospitalized for symptomatic HF, confirmed by the cardiologist, with evidence for underlying heart disease. Reasons for exclusion were invasive intervention within the last 6 months or planned the next 3 months, inclusion in another study with additional visits to a healthcare professional or evaluation for heart transplantation. After written informed consent, patients were interviewed by an independent data collector who was not involved in care for the patients. The study was designed to evaluate the effect of education and counselling by an HF nurse, on mortality and readmission for HF. Patients were randomized into care as usual (visits to the cardiologist only) or basic or intensive support by the HF nurse with a fixed follow-up period of 18 months. Data were collected at baseline before randomization, and 1, 6, 12, and 18 months after discharge of the index admission. According to Multidisciplinary Heart Failure Guidelines in The Netherlands, which comply with the ESC HF guidelines,[2] patients were instructed about sodium-restricted diet, fluid restriction, regularly weighing, and exercise during the index hospitalization. Patients in both intervention groups received comprehensive education about sodium and fluid restriction, including a brochure with practical advice about how to restrict their sodium and fluid intake. A special HF diary was developed and patients in both intervention groups were instructed to weigh daily, write down their weight in the diary and contact the HF nurse in case of a rapid weight gain or other symptoms of deterioration. They also were encouraged to exercise at least 30 min every day (walking, biking, housework). In case of severe HF, patients were instructed to divide these 30 min over the day within their own capabilities.

The study complied with the Declaration of Helsinki. The Ethics Committee approved the research protocol. The design and the main results of COACH are described in detail previously.[10,11]

Because slightly more than 50% of patients in COACH, were enrolled after a first diagnosis of HF during the index hospitalization, they could not be evaluated for compliance with non-pharmacological recommendations at baseline. Data on compliance were therefore collected 1 month after discharge. Patients with a primary endpoint before this point of time were excluded from the study. The time to first major event (hospitalization or death) was adjusted by subtracting 30 days of the original time to event.

Study measurements

Clinical and demographic variables

Clinical variables were collected from the patients' medical record at baseline and during the 18 months follow-up of the study. Demographic variables were assessed at baseline and were collected by interviews by an independent data collector. Depressive symptoms were measured with the Centre for Epidemiological Studies Depression scale (CES-D), which is a 20-item scale measuring depressive feelings and behaviours. A score of $\geq$16 is an indication for the presence of depressive symptoms.[12]

Measurement of compliance

Compliance at 1 month was measured with the Revised Heart Failure Compliance Questionnaire which measures compliance with daily weighing, sodium-restricted diet, fluid restriction, and exercise.[13] Compliance with diet, fluid restriction, and exercise was measured using a five-points scale (0 = never; 1 = seldom; 2 = half of the time; 3 = mostly; 4 = always) and compliance with daily weighing using a four-points scale (0 = daily; 2 = three times a week; 3 = once a week; 4 = less than once a week). Patients were defined as compliant with a specific recommendation when they followed that recommendation 'mostly' or 'always' (Score 3 or 4) or when they reported to weigh daily or three times week (Score 0 or 1). When patients followed a recommendation 'half of the time' (Score 2), they were considered as non-compliant. An overall score for compliance was calculated by summing the four different scores of compliance with the non-pharmacological treatment. Patients were considered 'overall compliant' when they reported to be compliant 'mostly' or 'always' with all four different components of the non-pharmacological recommendations.

Mortality and readmission for heart failure

The study had two primary endpoints; the first primary endpoint was a composite of HF hospitalization or death from any cause. The second primary endpoint was the number of unfavourable days, defined as the number of days the patient was hospitalized for HF or death during the 18 months follow-up period of the study. The second primary endpoint was the number of unfavourable days, defined as the total number of days during the follow-up period of 18 months, the patient was dead or in hospital due to HF.

Secondary endpoints of the study were the individual components of the primary endpoint, all-cause mortality, and hospitalization for HF. All reported endpoints were referred to and judged by an independent endpoint committee.

Statistical analysis

Descriptive statistics were used to characterize the study population. Normality of continuous variables was assessed by Kolmogorov–Smirnov test. χ^2 tests were used for categorical variables and Mann–Whitney tests for continuous variables that were not normally distributed.

Cox proportional hazard regression modelling were used to calculate the association of compliance with the HF regimen with time to primary endpoint, time to death, and time to HF hospitalization. All analyses initially included clinically relevant variables to account for potential confounding of the association between compliance and outcome [age, New York Heart Association (NYHA) functional class, coronary artery disease, stroke, diabetes, previous HF admission, left ventricular ejection fraction (LVEF), use of beta-blocker and digoxin, depressive symptoms, history of atrial fibrillation (AF), and creatinine]. Although there was a significant difference between compliant and non-compliant patients in LVEF, beta-blocker, digoxin, depressive symptoms, history of AF, and creatinine, these variables did not affect the association between compliance and outcome.

We formally evaluated for interaction between compliance and both age and NYHA functional class but no interaction was found.

Differences in total compliance scores were calculated using χ^2 tests. Differences in mean unfavourable days, mean number of hospitalizations for HF, and mean days in hospital with HF were calculated using Mann–Whitney tests. All patients ($n = 830$) were included in these analyses. χ^2 tests were used to assess differences in percentage of reached endpoint between compliant and non-compliant patients. A *P*-value <0.05 was considered as statistical significant. All analyses were performed with SPSS version 16.0.

Results

Clinical and demographic data

In total, 1023 patients were included in the COACH study. Ninety-four patients had a primary endpoint before 1 month after discharge of the index hospitalization and were therefore not included in the analysis; 58 patients had an HF readmission and 36 patients died. Of the remaining 929 patients, 99 did not complete the Revised Heart Failure Compliance Questionnaire, so the present analysis was performed in 830 patients. No significant differences in gender, age, and LVEF were found between 830 patients in the substudy and 193 patients who were not included in the substudy. The mean age of patients in the study was 70 ($\pm$11) years. Half of the patients were in NYHA II at the time of discharge, and 39% had depressive symptoms at baseline, during the index hospitalization (*Table 1*).

Compliance with non-pharmacological recommendations

A total of 48% of patients were compliant with all four non-pharmacological recommendations, meaning that they reported to comply 'always' or 'most of the time' on all four components of the regimen. With regard to the individual components, 83% of patients were compliant with weighing, 90% with diet and fluid restriction, and 60% of all patients reported to be compliant with recommendations on exercise.

Overall non-compliant patients were significantly older (72 vs. 68 years; $P < 0.01$) were more often in NYHA functional class III–IV (53 vs. 42%; $P < 0.01$), more often had a previous HF readmission (37 vs. 27%; $P < 0.01$), and more often reported depressive symptoms (43 vs. 35%; $P = 0.03$) (*Table 1*). Non-compliant patients were also less often in the intervention groups of the study (58 vs. 77%; $P < 0.01$). This was in line with the design of the COACH trial, since more emphasis on compliance was given, especially in the intensive intervention arm of the study. Similar patterns were seen for differences between patients who were compliant and non-compliant with exercise (*Table 1*).

Relation between compliance and mortality or heart failure hospitalization

Patients who were overall non-compliant with the non-pharmacological recommendations had an increased risk for the composite endpoint of death or HF hospitalization [adjusted hazard ratio (HR) 1.40; 95% CI 1.08–1.82; $P = 0.01$] (*Figure 1* and *Table 2*). Data were adjusted for New York Heart Association (NYHA) functional class, coronary artery disease, stroke, diabetes, previous HF admission, and age. In *Table 2*, unadjusted and adjusted hazard ratios are presented. The full multivariable analysis for the association of overall non-compliance and primary endpoint (death or HF readmission) was presented in *Table 3*.

During the study period from 1 month after discharge to 18 months after discharge, a total of 267 of the 830 (32%) patients reached the primary endpoint of death or HF hospitalization; 95 patients died and 172 patients were readmitted for HF. Twenty-five percent of patients who complied with all four aspects of the non-pharmacological regimen ($n = 98$) reached a primary endpoint during the 18 months of the study vs. 39% of patients who complied with three aspects and 45% who complied with one or none of the aspects of the non-pharmacological regimen (*Figure 2*). Overall difference in reached endpoint between patients who complied with all four aspects of the regimen and patients who complied with less than four aspects was statistically significant ($P < 0.01$). In addition, it was found that there were significant differences in percentages reached endpoint between patients who complied with the complete HF regimen, compared with those who complied with three, two, or one or none of the aspects (*Figure 2*).

Analysing the separate components of compliance, only a significant association between compliance with exercise and the primary endpoint was found. After adjusting for NYHA functional class, coronary artery disease, stroke, diabetes, previous HF admission, and age, patients non-compliance with exercise was associated with an increased risk for mortality or HF readmission (HR 1.48; 95% CI 1.15–1.91; $P = 0.002$) (*Table 2*).

In *Figure 3*, survival curves for the individual components of the total compliance measurements are presented.

No relationship was found between compliance with diet, fluid restriction, or daily weighing and the first primary endpoint.

Unfavourable days

Patients who were overall non-compliant with the non-pharmacological regimen had more unfavourable days than compliant patients (75 ± 147 vs. 43 ± 112; $P < 0.01$) (*Figure 4*). Analysing the separate components of the compliance score, we only found differences in unfavourable days in daily weighing; patients who were non-compliant with daily weighing had significantly more unfavourable days compared with compliant patients (100 ± 168 vs. 52 ± 124; $P < 0.01$).

Mortality

Although non-compliant patients tended to have an increased risk for mortality, this association was not statistically significant (HR 1.38; 95% CI 0.98–1.94; $P = 0.07$). However, we found a significant association between mortality and non-compliance with daily weighing (HR 1.57; 95% CI 1.08–2.27; $P = 0.02$). All data were adjusted for NYHA functional class, coronary artery disease, stroke, diabetes, previous HF admission, and age. We did not find a relationship between compliance with the other separate components of the HF regimen and mortality.

Hospitalization for heart failure

We found a significant association between overall compliance and HF hospitalization in this cohort (HR 1.38; 95% CI 1.00–1.91; $P = 0.05$). Non-compliant patients had significantly more mean HF

Table 1 Baseline characteristics of the study population

	Total ($n = 830$)	Compliant overall ($n = 389$)	Non-compliant overall ($n = 413$)	*P*-value	Compliant exercise ($n = 491$)	Non-compliant exercise ($n = 322$)	*P*-value
Age ± SD	70 ± 11 (830)	68 ± 12	72 ± 12	<0.01	69 ± 12	72 ± 13	<0.01
Sex, female	306 (37%)	35%	38%	0.41	34%	41%	0.03
Living with a partner	506 (62%)	64%	59%	0.24	62%	61%	0.82
LVEF ± SD	34% ± 14 (753)	32% ± 12	35% ± 15	0.02	33% ± 14	34% ± 15	0.26
Aetiology of HF							
Ischemic	336 (40%)	38%	44%	0.09	38%	44%	0.16
Non-ischaemic	494 (60%)	62%	56%		62%	56%	
Previous HF admission	261 (31%)	26%	37%	<0.01	28%	37%	0.01
NYHA functional class at discharge							
II	432 (53%)	58%	47%	<0.01	58%	45%	<0.01
III–IV	382 (47%)	42%	53%		42%	55%	
Co-morbidities							
Hypertension	354 (43%)	41%	45%	0.2	42%	44%	0.45
Diabetes	224 (27%)	23%	32%	<0.01	23%	34%	<0.01
COPD	210 (25%)	24%	26%	0.52	24%	27%	0.32
Stroke	72 (9%)	6%	11%	<0.01	6%	13%	<0.01
Medication at discharge							
ACE-inhibitor	618 (74%)	76%	73%	0.38	76%	72%	0.28
ARB	96 (12%)	12%	12%	0.9	12%	12%	0.83
Beta-blocker	554 (67%)	72%	62%	<0.01	70%	62%	<0.01
Digoxin	246 (30%)	25%	33%	0.02	27%	33%	0.12
Aldosteronantagonist	459 (55%)	56%	56%	0.85	54%	58%	0.27
BNP	630 ± 682 (630)	608 ± 679	654 ± 698	0.3	612 ± 672	656 ± 705	0.42
Creatinine	123 ± 50 (811)	118 ± 50	127 ± 49	<0.01	118 ± 47	129 ± 52	<0.01
History of AF	354 (43%)	47%	38%	0.01	40%	46%	0.09
Depressive symptoms (CES-D > 16)	305 (39%)	35%	43%	0.03	36%	43%	0.05
Intervention group	577 (67%)	77%	58%	<0.01	71%	62%	<0.01

LVEF, left ventricular ejection fraction; NYHA, New York Heart Association Functional Class; ACE, angiotensine converting enzyme; ARB, angiotensine receptor blocker; BNP, brain natriuretic peptide; AF, atrial fibrillation.

hospitalizations in the course of the study compared with compliant patients (0.31 ± 0.73 vs. 0.19 ± 0.53; $P = <0.01$) ($n = 830$). They also spend more mean days in hospital for HF than compliant patients (4.3 ± 11.3 vs. 2.6 ± 8.7; $P = 0.01$) ($n = 830$). Patients who did not comply with advice regarding exercise had an increased risk for HF hospitalization (HR 1.55; 95% CI 1.13–2.13; $P < 0.01$), had significantly more HF readmissions (0.35 ± 0.77 vs. 0.18 ± 0.52; $P < 0.01$), and were significantly more days hospitalized for HF (5.1 ± 12.5 vs. 2.4 ± 8.2; $P < 0.01$) ($n = 830$).

Discussion

The main finding of the present study is that a lack of compliance with non-pharmacological recommendations is associated with adverse outcome in patients with chronic HF.

Whereas compliance with drug treatment has received increasing attention recently, compliance with lifestyle recommendations and the association with clinical outcome has not been examined well. The present study is the first prospective study that found an independent association between compliance with non-pharmacological recommendations and morbidity and mortality in HF patients.

Patients who were overall compliant with the non-pharmacological recommendations had fewer HF readmissions and fewer days in hospital for HF compared with non-compliant patients. For the separate components of the compliance score, we also found a significant reduction in time to death or HF readmission in patients who were compliant with exercise and daily weighing and a reduction in unfavourable days for patients who complied with daily weighing. For the other separate components (fluid restriction and diet) of the HF regimen, there was no association between compliance and mortality or HF hospitalization.

Compliance with all four aspects of the regimen was low (48%) in this study, however, compliance with diet and fluid restriction was high, with 90% of patients who reported to be compliant.

Because of this lack of variance in compliance, it was not possible to investigate whether or not there was an association between compliance with diet and fluid restriction and clinical outcome. Although recommended in the guidelines, until now there are no studies showing clinical benefit of sodium and fluid restriction.

In the Cox regression analysis, the strongest association with outcome was found for compliance with exercise, although compliance with daily weighing also was significantly associated with improved outcome.

These data on compliance with non-pharmacological recommendations complement the existing literature on medication compliance. A recent study of Wu *et al.*[7] found that patients who complied with HF medication had a longer event-free survival compared with patients who were non-compliant with medication.

In our study, we found better outcomes in compliant patients compared with patients who were non-compliant with the non-pharmacological regimen. Reasons for the better outcomes of compliant patients are probably multi-factorial. In the first place, patients who complied with recommendations on daily weighing probably detected the worsening of symptoms in an earlier stage. In combination with an easy access to the HF nurse for

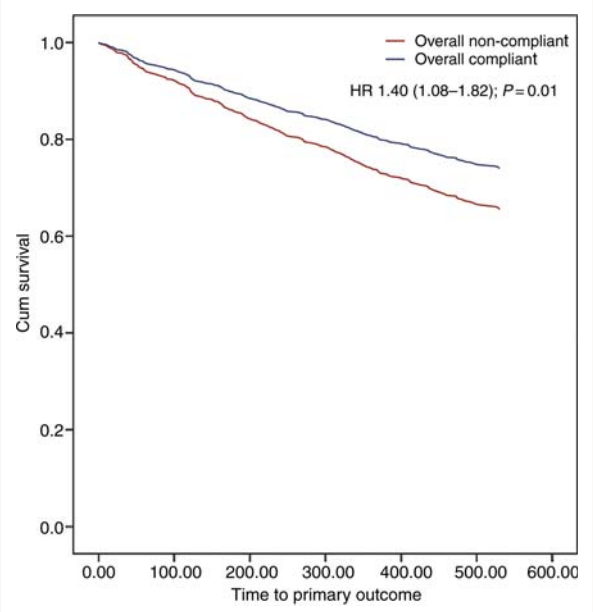

Figure 1 Survival curves for time to primary endpoint (mortality or readmission for HF) (adjusted for age, NYHA functional class, stroke, diabetes, coronary artery disease, and previous HF admission).

Table 2 Unadjusted and adjusted hazard ratio for time to death, heart failure readmission, and primary endpoint

	Unadjusted HR (95% CI)	Adjusted HR (95% CI)[a]	*P*-value[b]
Overall non-compliance			
Time to death	1.80 (1.30–2.50)	1.38 (0.98–1.94)	0.065
Time to HF readmission	1.65 (1.21–2.25)	1.38 (1.00–1.91)	0.049
Time to primary endpoint	1.71 (1.33–2.19)	1.40 (1.08–1.82)	0.011
Non-compliance weighing			
Time to death	2.08 (1.47–2.94)	1.57 (1.08–2.27)	0.02
Time to HF readmission	1.03 (0.67–1.58)	0.93 (0.60–1.44)	0.76
Time to primary endpoint	1.45 (1.08–1.95)	1.20 (0.87–1.65)	0.27
Non-compliance exercise			
Time to death	1.63(1.19–2.24)	1.24 (0.89–1.72)	0.20
Time to HF readmission	1.82 (1.35–2.47)	1.55 (1.13–2.13)	0.007
Time to primary endpoint	1.78 (1.40–2.27)	1.48 (1.15–1.91)	0.002

CI, confidence interval.
[a]Adjusted for age, coronary artery disease, NYHA functional class, previous HF admission, age, diabetes, stroke.
[b]*P*-value for hazard ratio after full adjustment.

Table 3 Unadjusted and adjusted hazard ratio for time primary endpoint

	Univariate HR (95% CI)	*P*-value	Adjusted HR (95% CI)[a]	*P*-value[b]
Overall non-compliance	1.71 (1.33–2.19)	<0.01	1.40 (1.08–1.82)	0.011
Age	1.02 (1.01–1.04)	<0.01	1.01 (1.00–1.03)	0.027
Coronary artery disease	1.53 (1.21–1.95)	<0.01	1.28 (1.00–1.65)	0.054
Previous HF admission	2.46 (1.94–3.13)	<0.01	1.95 (1.51–2.51)	<0.01
NYHA 1–2/3–4	1.65 (1.29–2.10)	<0.01	1.37 (1.07–1.77)	0.015
Diabetes	1.72 (1.34–2.21)	<0.01	1.43 (1.10–1.85)	<0.01
Stroke	1.69 (1.18–2.40)	<0.01	1.42 (0.98–2.07)	0.063

CI, confidence interval.
[a]Adjusted for age, coronary artery disease, NYHA functional class, previous HF admission, age, diabetes, stroke.
[b]*P*-value for hazard ratio after full adjustment.

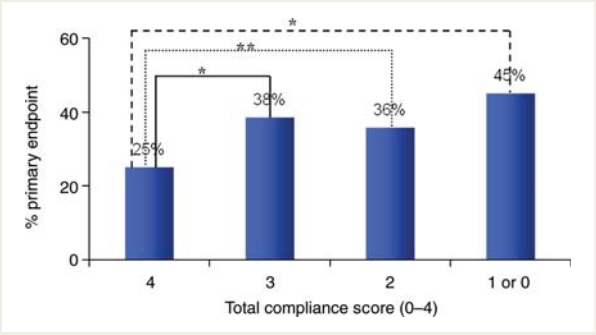

Figure 2 Percentage of patients with a primary endpoint, divided in number of non-pharmacological recommendations patients complied with (range 4–0) (4 = compliant with all aspects; 0 = compliant with none of the aspects). *$P < 0.01$; **$P < 0.05$.

patients in the intervention groups, this resulted in an earlier adjustment in the medical treatment and therefore in better outcome. Secondary, patients who are compliant with for example diet and exercise, in general may have a healthier lifestyle, such as less alcohol use and non-smoking, which might have influenced outcomes. A study of Evangelista *et al.*[14] found that non-compliance with smoking and alcohol restrictions increased the risk for multiple hospital readmissions among patients with HF. In the CHARM trial, lower mortality rates were found for patients who were adherent to study medication, independent of randomization (candesartan and placebo).[6] These results suggest that compliance with study medication is a marker for compliance with other effective treatments or for healthier behaviours in general (e.g. non-smoking, exercise, limited alcohol intake), resulting in better outcomes.[15] In our study, this explanation can be extended by the finding that patients who were compliant with the non-pharmacological treatment, also

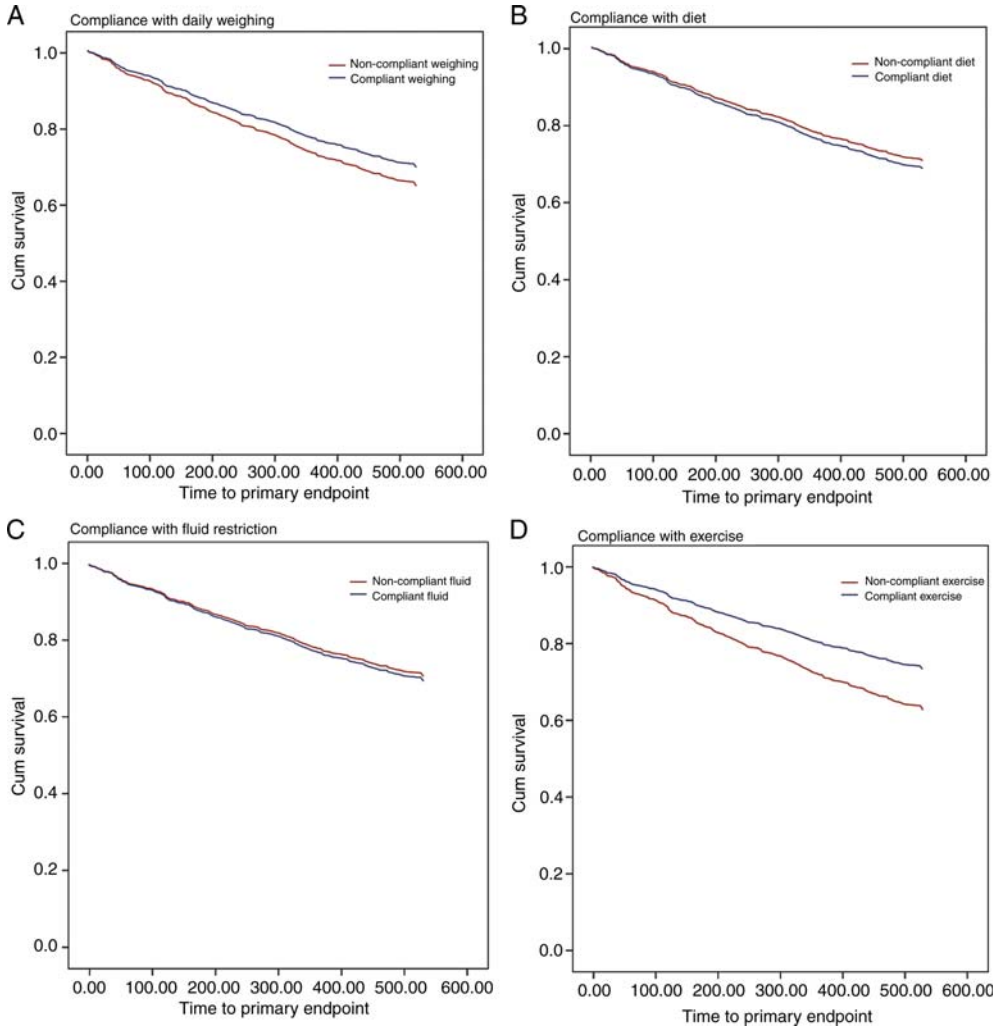

Figure 3 Survival curves for time to primary endpoint (mortality or readmission for heart failure) for compliance with daily weighing (*A*), compliance with diet (*B*), compliance with fluid restriction (*C*), and compliance with exercise (*D*) (adjusted for age, NYHA functional class, stroke, diabetes, coronary artery disease, and previous heart failure admission).

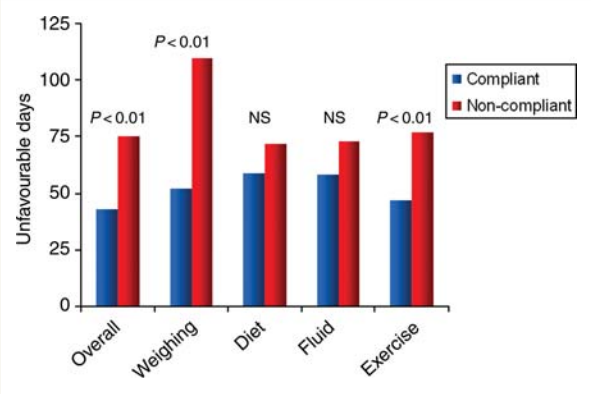

Figure 4 Number of unfavourable days (days lost to death or HF readmission) for compliant and non-compliant patients ($n = 830$).

might have been more compliant to medication, leading to better outcome.

Finally, we found a low compliance with exercise recommendations in this population (60%). Non-compliance with exercise was associated with higher rates of mortality or HF readmission. It is known that exercise training can be effective in reducing the combined endpoint of mortality and morbidity in patients with HF.[16] At first sight, one might think that patients who were non-compliant with exercise were those patients in a bad condition, e.g. with a higher NYHA functional class, and therefore had worse outcome, however, we found an independent relationship between non-compliance with exercise and worse outcome, since we corrected for NYHA functional class and other variables that were identified as confounders in the association between compliance and outcome. In the recently presented HF-ACTION trial on the effect of exercise training in stable HF patients, only 30% of patients fully complied with the exercise intervention,[17] and those who did report a higher volume of exercise had better outcomes. This might suggest that improvement of compliance with exercise is one of the most important aspects of education and counselling in HF patients.

Limitations of the study

A limitation of the current study was that almost half of the patients in the study had a first diagnosis of HF during the index hospitalization and that patients were evaluated for compliance at 1 month after discharge, which could have influenced their compliance rates. Therefore, the results of the study cannot be generalized to the whole HF population.

Secondly, since this study was not designed to prospectively follow compliant and non-compliant patients, the results should be interpreted with caution. Another point is that the rather novel endpoint 'unfavourable days', although used in previous publications, might be challenging to interpret.

Finally, a self-reported questionnaire was used in this study to measure compliance. It is possible that patients overestimated their actual compliance because of a tendency to give socially desirable answers. Another explanation is that patients were not able to estimate their actual compliance because of a lack of knowledge or skills needed to follow a low sodium diet as was suggested by Chung *et al.*[18] In their study, compliance with the low sodium diet was assessed objectively using 24 h urinary sodium excretion. It was found that patients failed to estimate their self-reported compliance with the low sodium diet.

Conclusion

In summary, we found that compliance with the non-pharmacological recommendations in HF patients indeed was associated with clinical outcome, e.g. mortality and morbidity. In heart failure management programs, it remains therefore important to emphasize the improvement of compliance with HF recommendations.

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CARDIOVASCULAR FLASHLIGHT

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Isolation of the right subclavian artery in interrupted aortic arch

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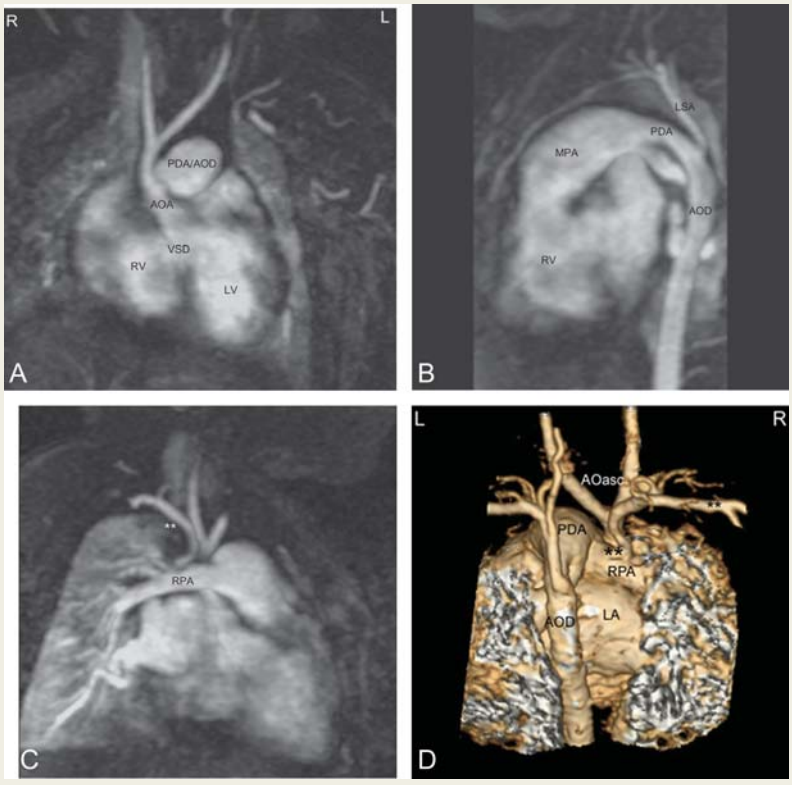
A 15-day-old newborn presented with cardiovascular shock. Upon clinical suspicion of congenital heart disease (CHD), medical treatment was initiated. Echocardiography showed a left-sided interrupted aortic arch Type B and a large ventricular septal defect (VSD). Magnetic resonance imaging (MRI) was requested for preoperative exact anatomical delineation of the interrupted aortic arch and of its branches. Additionally, MR angiography depicted an isolated right subclavian artery originating from the right pulmonary artery (*Figure*). Two days later, the patient underwent successful surgical repair with reconstruction of the aortic arch, VSD-closure, and re-implantation of the right subclavian artery into the aortic arch.



Origin of the subclavian artery from the pulmonary artery is a rare anomaly of the aortic arch. It is defined as a loss of continuity between the subclavian artery and the aorta, with a persistent connection to the homolateral pulmonary artery through a patent ductus arteriosus. It is mostly associated with intracardiac or aortic arch anomalies. Embryologically, isolation of the subclavian artery always occurs on the contralateral side of the aortic arch. The right subclavian artery is four times less frequently involved than the left one. This lesion is usually asymptomatic and mainly recognized during evaluation of CHD. Patients may present with diminished blood pressure or lower oxygen saturation in the involved arm; pulmonary or subclavian steal syndrome can occur.

The incidence of microdeletion 22q11 in patients with interrupted aortic arch is 55%. In patients with an additional anomaly of the subclavian artery, the incidence may rise up to 81%.

Figure. Contrast-enhanced MR angiography: (*A*) anterior view, (*B*) left anterior oblique view, (*C*) right anterior oblique view, (*D*) 3D reconstruction, posterior view. Double asterisks show right subclavian artery arising from RPA. LSA, left subclavian artery; RPA, right pulmonary artery; AOA, ascending aorta; AOD, descending aorta; LV, left ventricle; RV, right ventricle; VSD, ventricular septal defect; PDA, persistent ductus arterious; MPA, main pulmonary artery; LA, left atrium.