



# Improved outcome with standardized plan for clinical management of acute decompensated chronic heart failure

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## Abstract

**Background** Our overall goal is to improve clinical care for inpatients with chronic heart failure (CHF). A retrospective assessment of CHF patients admitted to our hospital over the past decade (2005 vs. 2014) indicated a need for better strategies to evaluate clinical treatment, implement best practices and achieve optimal patient outcome. To that purpose, we developed a standardized plan to improve in-hospital treatment of acute decompensated CHF patients. **Methods & Results** Retrospective chart reviews were conducted to compare three cohorts of CHF patients admitted to the University Hospital of Lund at different time points over a 12-year period: 2005 (365 patients), 2014 (172 patients) and 2017–2018 (57 patients). Little improvement was seen between 2005 and 2014 with respect to one-year mortality (35% vs. 34%) and adequate treatment with recommended medications, e.g., use of renin-angiotensin system blockers (45% vs. 51%). A standardized treatment plan was devised to improve outcomes. A third cohort, treated under the plan (2017–2018), was compared with the 2014 cohort. One-year mortality (18% vs. 34%) and 30-day readmission (5% vs. 30%) were dramatically decreased, and adherence to medication guidelines was achieved. Key elements of the plan included well-defined treatment procedures, enhanced communication and teamwork, education, adequate time for treatment (5 days) and post-discharge follow-up as necessary. Natriuretic peptide (NT-proBNP) levels were useful for assessing patient status, prognosis and response to treatment. **Conclusion** Development of a standard plan for clinical management of acute decompensated CHF patients resulted in significant improvements in patient outcome, as reflected in decreased rates of 30-day readmission and one-year mortality.

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## 1 Introduction

During the last decades, great progress has been made in the overall treatment and management of cardiac disease; however chronic heart failure (CHF), a common endpoint for many types of cardiac disease,<sup>[1,2]</sup> remains a complicated health problem. Prevalence of CHF is high, affecting 2%–3% of the adult population in the Western world.<sup>[2,3]</sup> CHF is also a significant financial burden, comprising about 2% of the total annual health costs in the developed world.<sup>[4]</sup> The incidence of CHF is expected to rise with the increasing number of elderly persons, who have the greatest risk for CHF.<sup>[5,6]</sup>

A number of treatments are available for managing CHF, including renin-angiotensin system (RAS) blockers,  $\beta$ -adrenergic blockers, aldosterone antagonists and the recently approved sacubitril/valsartan,<sup>[7]</sup> as well as coronary revascularization, devices such as defibrillators and mechanical therapy.<sup>[8]</sup> However, the overall prognosis for those with CHF remains poor, with a 5-year mortality rate of 47%–60% that is comparable to many cancers.<sup>[5]</sup> A significant proportion of CHF patients are elderly (> 80 years of age), frail, and they commonly have co-morbidities such as cardiovascular disease, e.g., atrial fibrillation, hypertension and ischemic heart disease, as well as renal insufficiency, pulmonary disease and diabetes mellitus.<sup>[5,9,10]</sup> These patients also tend to have a lower tolerance for the standard dose of CHF medications,<sup>[11,12]</sup> and they often end up with frequent episodes of acute decompensated heart failure that require hospitalization.<sup>[1,5]</sup>

Elderly patients with CHF comprise a majority of those seeking acute medical care at our emergency clinic for in-

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ternal medicine at the University Hospital of Lund. We previously described a cohort of such patients from 2005 in a study that established N-terminal pro B-type natriuretic peptide (NT-proBNP) as a predictor of prognosis in elderly CHF patients.<sup>[13]</sup> In this cohort, the patients were of advanced age (mean age, 80 years), had a poor prognosis (one-year mortality, 35%), and often received no, or suboptimal, treatment with the medications recommended for CHF. The original goal of the present study was to use our 2005 cohort as a baseline to assess how the treatment and prognosis for CHF patients in an acute, inpatient setting may have changed over the past decade, particularly in light of a wider emphasis on professional guidelines for diagnosis and treatment,<sup>[8,14,15]</sup> increases in generic and novel options for drug treatment, and increased use of NT-proBNP measurements in the management of CHF.<sup>[16]</sup> To that end, we conducted a retrospective review of a novel, but similar, demographic cohort of CHF patients that had been admitted to our clinic approximately 10 years later (2014).

In reviewing these data, it was apparent that not much had changed. This finding prompted a critical analysis of how CHF patients were managed in our clinic, and that led to our development of a standardized treatment plan that would incorporate recommended guidelines and best practices.<sup>[8,14,15]</sup> After the plan was implemented, we analyzed a third cohort of CHF patients admitted to our clinic (2017–2018) in order to determine the impact of the plan on patient outcomes. In spite of similar patient characteristics

and disease severity among the three cohorts, inpatients that were managed under the standard plan showed a dramatic improvement in the rates of 30-day hospital readmission and one-year mortality.

## 2 Methods

Descriptive, retrospective cohort studies were conducted using data from hospital medical charts for patients admitted to the University Hospital of Lund, Skåne, Sweden. Permission to read patient charts was given by the Hospital's Medical Director of Emergency Medicine and Internal Medicine. The studies conformed to the principles outlined in the Declaration of Helsinki and were approved by the Lund University Ethics Committee, permission DNR 2016/819.

The 2005 cohort of 365 patients consisted of 184 men and 181 women. The second cohort (2014) consisted of 172 patients, 98 men and 77 women. The third cohort from 2017–2018 consisted of 57 patients, 33 males and 24 females (Table 1).

Inclusion criteria: (1) hospitalization at the University Hospital of Lund due to acute decompensated heart failure, (2) CHF listed as the primary diagnosis at discharge, and (3) record of NT-proBNP measurements made at the time of admission.

Exclusion criteria: other types of severe acute conditions in addition to acute decompensated HF, such as myocardial

**Table 1. Characteristics, medications and outcomes for three inpatient CHF cohorts reflecting a 12-year period, with and without the standard treatment plan.**

Inpatient treatment	CHF cohorts		
	<i>Ad Hoc</i> treatment		Standard plan
	2005* ( <i>n</i> = 365)	2014 ( <i>n</i> = 172)	2017–2018 ( <i>n</i> = 57)
Mean age, yrs	80	82	82
Male/Female	51%/49%	57%/43%	58%/42%
CHF diagnosis			
NYHA class IV	71%	76%	100%
Mean NT-proBNP at admission, ng/L	-	10,057	9,775
Drug treatment (% of patients)			
ACEi/ARB	45%	51%	86%
β-Blocker	40%	70%	88%
Spironolactone	67%	33%	42%
Loop diuretic	100%	100%	88%
Outcomes			
30-day readmission	-	30%	5%
1-year mortality	35%	34%	18%

\*Data taken from Andersson *et al.*, 2008<sup>[13]</sup>. ACEi: angiotensin converting enzyme inhibitor, ARB: angiotensin receptor blocker; CHF: chronic heart failure; NT-proBNP: N-terminal pro B-type natriuretic peptide; NYHA: New York Heart Association.

infarction or sepsis at the time of admission or during the follow-up period. Analysis of NT-proBNP levels were performed at the Department of Clinical Chemistry, University Hospital of Lund using the Elecsys system (Roche Diagnostics Basel Switzerland). In reviewing the charts, the following factors were noted for the patients at the time of admission: age, sex, cause of CHF, presence of common comorbidities, level of NT-proBNP, NYHA class, estimated glomerular filtration rate (eGFR) according to Cockcroft-Gault, body mass index (BMI), and systolic and diastolic blood pressures. In the follow-up assessment after discharge, the following parameters were noted for each patient: survival and time to readmission due to recurring acute decompensated heart failure.

For all statistical analyses of data from the three cohorts, SPSS version 17.0 was used. Normal distribution was assumed. A *P*-value of < 0.05 was considered statistically significant. Data from the 2014 and 2017 cohorts were compared with the Mann-Whitney *U* test.

### 3 Results

#### 3.1 Basic characteristics

Patient characteristics were remarkably similar for the CHF cohorts of 2005, 2014 and 2017–2018 (Table 1). The mean age was not different among the groups (> 80 years), affirming that it is elderly patients that consistently present with acute decompensated HF. The male/female ratio also was quite consistent across the three cohorts, with only slightly more men than women represented in the groups.

It is important to note that the severity of CHF at the time of admission also was similar among the three cohorts (Table 1). Over 70% of the patients in all cohorts were in the most severe NYHA class of HF, IV; and actually 100% of patients in the 2017–2018 cohort were classified as NYHA IV. For the remainder of the patients in the 2005 and 2014 cohorts, the majority was classified as NYHA III. Consistent with the NYHA classification, blood levels of NT-ProBNP at the time of admission were found to be quite high (around 10,000 ng/L) in both the 2014 and 2017–2018 cohorts.

For all cohorts, ischemic heart disease was by far the most common cause of acute decompensated CHF and essential hypertension was the second most common cause. Co-morbidities were quite frequent in patients from all cohorts, with the most frequent conditions being atrial fibrillation and diabetes mellitus. Almost all of the patients admitted with decompensated acute HF were treated in the hospital's acute Internal Medicine wards; only a few were cared

for in a specialized cardiac ward (4% in 2005, 6% in 2014, none in 2017–2018).

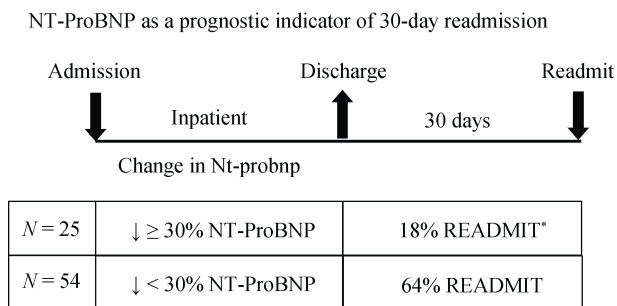
#### 3.2 Comparison of 2005 and 2014 cohorts

Our initial goal was to determine whether there had been any improvement in patient outcomes in the decade since we first assessed CHF patients hospitalized in 2005.<sup>[13]</sup> We compared the mortality rate for patients in the 2005 and 2014 cohorts (Table 1). At the time of the one-year follow-up, 34% of patients in the 2014 cohort were deceased, indicating the one-year mortality rate had not changed from that reported previously for CHF patients in the 2005 cohort (35%).<sup>[13]</sup>

Furthermore, as seen in Table 1, patients in both the 2014 and 2005 cohorts were under-treated with respect to CHF medications recommended by professional guidelines, such as those by the European Society of Cardiology.<sup>[8]</sup> In particular, there was very little change in the number of patients prescribed RAS inhibitors [angiotensin converting enzyme inhibitors (ACEI), and angiotensin receptor blockers (ARB)]: 45% in 2005<sup>[13]</sup> and 51% in 2014. There was an increase in the number of patients receiving  $\beta$ -adrenergic blockers in 2014 (70% vs. 40%), however 30% of the patients remained untreated with this medication. Moreover the prescribed doses of  $\beta$ -adrenergic blockers and RAS inhibitors were quite low for the 2005 and 2014 cohorts, with median dosage being < 50 % of what is considered the target dose by the European Society of Cardiology.<sup>[8]</sup>

Frequent hospitalization, measured as the 30-day readmission rate, is a known indicator of severe disease among patients with CHF.<sup>[5]</sup> Chart review of the 2014 cohort revealed a relatively high number of CHF patients being readmitted due to cardiac problems within 30 days of discharge (30%). This determination that had not been made for the 2005 cohort.<sup>[13]</sup> However, we previously reported on the prognostic value of monitoring NT-proBNP levels in elderly CHF patients,<sup>[13]</sup> so we re-examined the 2014 cohort to see if there was any relationship between NT-proBNP measurements and 30-day readmission (Figure 1). Of the 79 patients for whom NT-proBNP had been measured both at admittance and discharge, 32% had a substantial lowering of NT-proBNP levels ( $\geq 30\%$  decrease) during their hospital stay. In this group of patients, 18% were readmitted within 30 days for cardiac causes. In contrast, patients who showed less than a 30% reduction in NT-proBNP during inpatient treatment had a significantly higher rate of 30-day readmission (64% for cardiac causes; *P* < 0.001 vs. those with  $\geq 30\%$  NT-proBNP reduction).

From the chart review of the 2005 and 2014 cohorts, there was little evidence of patient follow-up after discharge.



**Figure 1. Inpatient improvement, defined as a 30% or more decrease in NT-ProBNP levels between time of hospital admission and discharge, was correlated with a significantly lower rate of readmission for cardiac problems in the 30 day period after discharge. Data from CHF patients in the 2014 cohort. \* $P < 0.001$ .** CHF: chronic heart failure; NT-ProBNP: N-terminal-pro B-type natriuretic peptide; READMIT: readmission to hospital.

Eight percent in 2005 were noted to have had follow-up visits at outpatient clinics for heart failure. Of the 2014 cohort, 4% were seen at a specialized CHF-oriented outpatient clinic after discharge.

### 3.3 Development and implementation of standard plan for hospital management of heart failure

The results of our retrospective review of CHF patients from 2005 to 2014 indicated a lack of progress in the hospital treatment of heart failure patients. It was hypothesized that treatment could be improved by consistent adherence to professional<sup>[8]</sup> and national CHF guidelines (Swedish National Guidelines for Cardiac Care, National Board of Health and Welfare, Socialstyrelsen) and best clinical practices. Thus, a standardized plan was developed for management of acute decompensated CHF patients in our hospital (Figure 1S).

### 3.4 Key elements of the plan

We based the standard plan on established guidelines for CHF treatment, best practices for clinical care,<sup>[8,14,15]</sup> and what had been learned from the current retrospective review and related published studies.<sup>[13]</sup> Key elements of the plan included clear treatment guidelines, defined roles and enhanced communication among the clinical team, education of clinical personnel as well as patients, adequate time to assess and treat the patient (five days), and scheduling of post-discharge follow-up visits as necessary. In particular, monitoring of plasma levels of NT-proBNP was used to assess patient status, prognosis and response to treatment.<sup>[13,16]</sup> Another important aspect was to insure that patients were entered into the national HF registry, a process that has been shown to improve outcome.<sup>[17]</sup>

An important objective was to present the plan in a clear, simple manner so it would be convenient to follow and encourage clinical personnel to review their roles and recommended practices. The plan was posted in the wards, along with a graphic we developed on how to assess the severity of CHF in line with the NYHA classification. To implement the plan, we used a “bottom up” approach and introduced it to one ward at a time. We started with a team of experienced and motivated doctors and nurses and provided hands-on education and guidance to the staff. The positive feedback from the staff, coupled with support from hospital administrators, has resulted in the standard plan becoming the standard of care for CHF patients admitted to the Internal Medicine wards at the University Hospital of Lund.

### 3.5 Comparison of cohorts before (2014) and after (2017–2018) use of the standard plan

Overall, comparison of the 2014 and 2017–2018 cohorts indicated a remarkable improvement in patient outcomes after implementation of the standard plan (Table 1). There was a significant decrease in the mortality rate for the year after discharge (18% in 2017–2018 vs. 34% in 2014). In addition, there was a dramatic drop in the rate of readmission in the 30 days after discharge (5% in 2017–2018 vs. 30% in 2014).

The patients in the 2017–2018 cohort also showed notable improvement with regard to drug treatment, and the medications they received now met the goals put forth in the National Swedish (Socialstyrelsen) guidelines for CHF. The majority of patients were prescribed both RAS inhibitors (86%) and  $\beta$ -adrenergic blockers (88%), and there was increased use of the aldosterone antagonist, spironolactone (42% in 2017 vs. 33% in 2014). Moreover, drug dosages in the 2017–2018 cohort achieved recommended levels, unlike what was found for the 2014 cohort. Interestingly, there was also a small decrease in the use of loop diuretics in the 2017–2018 cohort (88% vs. 100% in 2014).

The patients of the 2017–2018 cohort spent  $\geq 5$  days in hospital. During that time, there was a coordinated effort for ongoing monitoring of the patient’s status as specified in the standard plan. In particular, repeated NT-ProBNP measurements were taken to follow the patient’s response to treatment. In accordance with the plan, patients were assessed at the time of discharge to review their status and prognosis. Patients who had responded with a lowering of NT-proBNP levels were discharged with education and the recommendation to continue with their current medications under the guidance of their regular doctor. Patients with a poor prognosis reflective of end-stage HF were referred for

palliative medicine and care. A third group of patients were identified as at risk for readmission and were scheduled for a follow-up visit within 14 days with members of the hospital team involved in the treatment plan, in particular, the HF doctor and nurse specialists. These clinicians, who were knowledgeable about the patient's recent history and had gained the patient's trust, were well-suited to honestly discuss with the patient how they were managing after discharge and make further recommendations.

## 4 Discussion

Chronic heart failure (CHF) is a significant health problem with increasing prevalence,<sup>[2,18]</sup> and poor prognosis that often leads to hospitalization. Management of CHF patients admitted to a clinical ward is challenging; these patients are usually elderly and often suffer from several chronic diseases.<sup>[19,20]</sup> Hospitalization as a result of acute decompensation of HF generally occurs in the severe stages of CHF. In the present retrospective study, the three CHF inpatient cohorts sampled from the past 12 years were remarkably consistent with this description. Thus, it was striking that after a decade of little change in patient outcomes, implementation of a plan for best standards of clinical treatment immediately and significantly improved patient prognosis, as evidenced by decreased rates of 30-day readmission and one-year mortality.

CHF patients constitute a significant proportion of the patients admitted to the Department of Emergency and Internal Medicine at the University Hospital of Lund. Thus, we undertook the present study to determine trends and outcomes in our treatment of CHF patients. A one-year mortality rate of 34% was found for the 2014 cohort, indicating no change from a similar cohort of a decade earlier<sup>[13]</sup> and comparable to published outcomes of the Framingham study from 2002.<sup>[5]</sup> Following implementation of the standard plan, one-year mortality fell by > 50% to a rate of 18% in the 2017–2018 cohort.

One likely contributor to the better outcomes in 2017–2018 was stricter adherence to CHF medication guidelines. In our study, CHF patients in both the 2005 and 2014 cohorts were significantly undertreated according to professional recommendations.<sup>[8,15]</sup> Similar findings have been reported by others.<sup>[21]</sup> For example in a review of the Get With the Guidelines-HF registry 2008–2013 with over 150,000 patients from 271 hospitals, it was reported that about 50% of those patients deemed eligible for treatment at discharge had not been taking either ACEi/ARB or  $\beta$ -adrenergic blockers at the time of admission.<sup>[21]</sup> In agreement with our

standard plan, these authors recommend that a key component of HF clinical care is a process to initiate recommended medications as needed as well as manage polypharmacy.<sup>[21]</sup>

Co-morbidities, fragility and increased risk of side effects in elderly patients with severe CHF may underlie a reluctance to prescribe the recommended drugs to these patients.<sup>[12,19,20,22]</sup> However, as evidenced by our 2017–2018 cohort with a mean age of 80 years and severe CHF (NYHA class IV), careful inpatient initiation, adjustment and use of CHF medications to recommended levels, as prescribed by the standard plan, correlated with better outcomes for these patients as compared to our earlier cohorts. Although few studies have systematically assessed the use of CHF drugs in the elderly, the general opinion is that this population does benefit when properly managed with ACEi/ARBs and  $\beta$ -adrenergic blockers.<sup>[12,23]</sup> While the use of CHF-specific medications increased, we also saw a decrease in the use of loop diuretics in the 2017–2018 cohort. This finding may reflect the more comprehensive nature of patient assessment under the plan, which included monitoring of patients' weight. The primary indication for diuretics is to improve symptomatic fluid overload, dyspnoea and edema in CHF patients,<sup>[8,23]</sup> and their use and dosage should be carefully considered in the elderly.<sup>[23]</sup>

Another important aspect of the standard plan was the use of the biomarker NT-proBNP for ongoing inpatient assessment and prognosis determination at discharge.<sup>[13,24–30]</sup> Data from our 2014 cohort validated the prognostic value of NT-proBNP for predicting readmission rates. Under the standard plan, NT-proBNP was measured at the time of admission, during hospitalization and at discharge and used to guide treatment decisions and discharge recommendations to optimize patient outcome. The length of the in hospital stay under the standard plan was at least 5 days, which allowed sufficient time for adequate management and stabilization of the patients.

In conclusion, CHF patients hospitalized with acute decompensated heart failure have a comparatively poor prognosis that appears to have remained relatively unchanged over the last decade. The patients are elderly and often treated with CHF drugs at levels far below target dosage, in particular, unsatisfactory treatment with RAS-blockers and  $\beta$ -adrenergic receptor blockers. Serial measurements of NT-proBNP, measured early at admittance in an acute setting, was useful for identifying patients with better prognosis, even within a demographic with unstable disease and frequent episodes of decompensation. Serial measurements of NT-proBNP during hospitalization due to decompensated heart failure facilitated decision-making with regard to

treatment and discharge.<sup>[13,20,22]</sup> The development and implementation of a standard plan using CHF guidelines and best practices of clinical care with a team approach made a significant improvement in outcome for patients hospitalized with decompensated HF.

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