Outcomes and the quality of care for patients hospitalized with heart failure

JEAN-CHRISTOPHE LUTHI1,2,3, W. DANA FLANDERS3, STEPHEN R. PITTS3, BERNARD BURNAND1 AND WILLIAM M. MccLELLAN3,4

1Institute of Social and Preventive Medicine, University of Lausanne, 2Health Observatory, Canton of Valais, Switzerland, 3Epidemiology Department, Rollins School of Public Health, Emory University, Atlanta, GA, 4Georgia Medical Care Foundation, Atlanta, GA, USA

Abstract

Objective. The purpose of this study was to determine whether process quality indicators derived from evidence-based guidelines for heart failure patients were associated with outcome indicators (hospital mortality and readmissions).

Design. A retrospective cohort-study among patients discharged with a primary or secondary International Classification of Disease, 10th revision (ICD-10) heart failure code from 1 January to 31 December 1999.

Setting. The study was implemented in three Swiss academic medical centers.

Study participants. Records of 1634 patients hospitalized with heart failure were abstracted. Demographic characteristics, risk factors, symptoms and findings at admission, and discharge characteristics were recorded.

Main outcome measure. Process quality indicators were derived from evidence-based guidelines, related to appropriate management and treatment of heart failure patients. Hospital mortality was measured in a chart abstraction process. Thirty-day readmissions were calculated using administrative data from hospitals.

Results. Among the three hospitals, 1153 patients with heart failure were eligible for this study. Mean age was 75.3 years (standard deviation 12.7) and 45.7% of patients were female. Ventricular function (VF) was determined in 69% of patients. The adjusted odds-ratios (OR) for the VF not determined were 1.74 [95% confidence interval (CI) 1.06–2.84] for hospital mortality and 0.75 (95% CI 0.47–1.18) for 30-day readmissions. Among patients with left ventricular systolic dysfunction and no contraindication to angiotensin-converting enzyme inhibitor (ACEI), 54% were prescribed target-dose ACEI or angiotensin receptor blockers at discharge, 32% received ACEI at less then target dose, and 14% received no ACEI at discharge. Adjusted ORs (95% CI) for readmissions were 0.89 (0.28–2.84) for no ACEI and 1.17 (0.56–2.43) for less than target ACEI compared with target dose.

Conclusions. Among patients with heart failure, the determination of VF was associated with hospital mortality. However, process indicators derived from evidence-based guidelines were not related to early readmissions in three Swiss university hospitals.

Keywords: heart failure, hospital mortality, outcome research, quality of health care, readmissions

Heart failure is a common and serious condition that affects >4 million people in the United States. Approximately 400 000 new cases are diagnosed each year [1], and mortality rates 1 year after diagnosis are 62% [2]. In Switzerland, ∼210 000 people have heart failure, of which 60% are treated and 47% receive angiotensin-converting enzyme inhibitors (ACEI) [3]. Because of this high prevalence, several professional groups have issued guidelines to optimize the diagnosis and management of this disease [1,4–8]. Several studies have shown that adherence to these clinical practice guidelines is still not optimal [9–12]. Furthermore, studies have shown that if physicians fail to manage and treat heart failure patients according to the evidence-based clinical guidelines, worse outcomes will be observed. An overview of 30 randomized clinical trials indicated that appropriate treatment for heart failure patients was effective in reducing the combined risk of mortality and hospitalization [13]. We have previously shown that failure to adhere to guidelines for ACEI prescription is associated with higher mortality and more readmissions among patients with left ventricular systolic dysfunction (LVSD) [14,15]. Quality of care should be regularly monitored and improved when needed. The availability of routinely collected data offers an opportunity for monitoring quality of care. The aim of this study was to examine the relationship...
between guidelines-based process quality indicators and outcomes (hospital mortality and readmissions), available from routinely collected data, among heart failure patients treated in three Swiss academic medical centers.

**Methods**

**Study design**

This was a retrospective cohort study of patients hospitalized for heart failure and discharged between 1 January and 31 December 1999 from three Swiss university hospitals. Outcome measures of interest were hospital mortality and 30-day readmissions. Follow-up for each patient began on the date of discharge from the hospital and continued for 30 days.

**Population**

Patients were identified through hospital administrative data sets if they were hospitalized with a principal or secondary diagnosis of heart failure [International Classification of Disease, 10th revision: I50.0, I50.1, I50.9, I11.0, I13.0, and I13.2 (ICD-10)]. We computer-generated a random number for each record. The data were then sorted by random number and the first 700 records with the lowest numbers were selected. In two hospitals we randomly selected 700 patients hospitalized with heart failure among 976 and 774 cases, respectively. In the third hospital, all 234 eligible patients registered in the administrative data system with a primary or secondary diagnosis of heart failure were included in the study. Patients were excluded from the sample if the initial hospitalization was terminated against medical advice, or if they were transferred to another acute care hospital. Additional exclusion criteria included diagnosis of valvular heart disease, acute myocardial infarction, cor pulmonale, chronic obstructive pulmonary disease treated with home oxygen, thiamine deficiency, amyloidosis, and thyrotoxicosis.

**Data**

Data were abstracted from medical charts by medical record specialists. The entire medical chart was available for abstraction in one hospital, the scanned medical record was used in another one, and the electronic medical record was used in the last one. A random replicate sample of 100 charts was abstracted to assess integrator reliability. The kappa estimate was 0.91 for the determination of the ventricular function (VF) and 1.0 for hospital mortality.

Variables abstracted from the chart included age, sex, smoking status, recorded history of previous heart failure, myocardial infarction, chronic obstructive pulmonary disease, bronchitis, emphysema, hypertension, and diabetes. Clinical information included a history of paroxysmal nocturnal dyspnea (PND), dyspnea on exertion (DOE), and orthopnea. Physical findings abstracted included renal edema, pulmonary rales, S3-gallop, and evidence of elevated jugular vein pressure. The final serum creatinine and potassium values recorded during the hospitalization were also considered, as well as the confirmation of the presence of heart failure in the admission chest X-ray report and of atrial fibrillation on the admission electrocardiogram (ECG). We also abstracted discharge medications, as well as the presence in the chart of discharge counseling for daily weight monitoring, low sodium diet, and smoking cessation. Information on hospital mortality and readmissions within 30 days were identified using administrative data sets from the hospitals. We assessed all cause readmissions and included only patients from the index hospital. Because these hospitals are university referral centers, each one for a different catchment area, we assumed that only a few patients could have been readmitted to a different hospital. Indeed, for one provider, we could assess that none of the patients were readmitted to another Swiss hospital using a unique identifier from the Swiss Federal Statistical Office.

**Quality indicators**

Process quality indicators were derived from evidence-based guidelines in collaboration with key clinicians [14].

**Determination of VF**

Patients with LVSD were identified by examining medical charts for a measure of the current (from the index hospitalization) or previous ejection fraction (EF) ≤40%. If no information regarding the EF was found, we searched for a narrative description in the chart. Specifically, the following terms were associated with LVSD: ‘systolic dysfunction’, ‘dilated cardiomyopathy’, ‘congestive cardiomyopathy’, ‘diffuse global hypokinesis’, or ‘systolic-diastolic dysfunction’ (patients reported to have both systolo-diastolic and diastolic dysfunction by cardiologists).

**Use of ACEI for patients with LVSD**

ACEIs were identified in the medical charts using generic or trade names, including Benazapril, Captopril, Enalapril, Fosinopril, Lisinopril, Quinalapril, Ramipril, Perindopril, and Cilazapril. We then re-grouped patients into three treatment groups to assess the process quality indicator related to ACEI treatment. The groups comprised patients prescribed target-dose ACEI or angiotensin-receptor blocker (ARB), less than target-dose ACEI, or no prescription of ACEI at discharge. Target levels were defined based on results from randomized control trials, which showed improved survival in patients with LVSD (Captopril 50 mg tds, Enalapril 10 mg bd, Lisinopril 20 mg qds, and Ramipril 5 mg bd) [16]. If target levels were not available from clinical trials, we used the following estimates based on the manufacturers’ stated average dose: Benazapril 20 mg qds, Fosinopril 20 mg qds, Quinalapril 10 mg bd, Perindopril 4 mg qds, and Cilazapril 1 mg qds [17]. We excluded from the study patients who experienced any of the following contraindications to ACEI: cough, renal insufficiency, skin rash, hyperkalemie, angio-edema, neutropenia, and hypotension related to ACEI. The following ARBs were recorded: Irbesartan, Candesartan, Losartan, Valsartan, Telmisartan, and Eporosartan.
β-blockers for systolic dysfunction

All β-blockers prescribed at discharge were recorded, and included Propranolol, Pindolol, Nadolol, Bobindolol, Oxprenolol, Sotalol, Atelolol, Metoprolol, Esmolol, Bisoprolol, Betaxolol, Nebivolol, Acebutolol, and Celiprolol. Patients with LVSD were identified in a similar manner as already described for the previous quality indicator. To calculate the quality indicators related to β-blocker prescription at discharge in patients with LVSD, patients with a contraindication(s) to β-blockers were excluded. Such contraindications included hypotension, asthma or chronic obstructive pulmonary disease (COPD), dementia, bradycardia, and bundle branch block.

Anticoagulation in patients with atrial fibrillation

Atrial fibrillation was recorded on the ECG reports during hospitalization. Anticoagulants prescribed at discharge were Acenocoumarol and Phenprocoumone. Quality indicators related to the prescription of anticoagulants at discharge were developed for patients with atrial fibrillation and no contraindications to anticoagulants (recent bleeding, hepatic disease, ethylism, coagulopathy, pregnancy, gastric ulcer, recent stroke, and allergy to anticoagulants).

The Charlson co-morbidity index was computed at index hospitalization for each patient as a severity of illness measure using the Deyo modification [18]. The Charlson co-morbidity index is a weighted average of selected co-morbidities.

Statistical analysis

Dichotomous outcome variables were hospital mortality and readmission within 30 days. Primary exposure variables were the different process quality indicators, the determination of VF, ACEI-treatment group at discharge in patients with LVSD (ACEI at target dose or any dose of ARB, ACEI at suboptimal dose, and no treatment with ACEI), β-blockers at discharge in patients with LVSD, and anticoagulants at discharge for atrial fibrillation. Other variables included in the analysis as potential confounding factors were: age, sex, history of heart failure, diabetes mellitus, hypertension, prior myocardial infarction, chronic obstructive pulmonary disease, smoking, Charlson co-morbidity index, symptoms and findings at admission [paroxysmal nocturnal dyspnea, dyspnea on exertion, orthopnea, leg edema, pulmonary rales, jugular vein distension (JVD), S3-gallop], atrial fibrillation, serum creatinine and potassium results, minimum ejection fraction, and length of stay at hospital.

We first conducted a bivariate analysis between the dependent and the primary exposure variables. We also calculated the crude risk ratio and 95% confidence intervals (CIs) for hospital mortality and 30-day readmissions. We used χ² tests, Fisher’s exact tests, Student’s t-tests, or analysis of variance (ANOVA) methods when appropriate.

Finally, we performed a multivariate analysis using logistic regression. Given the small sample sizes and the large number of confounding factors, we used a priori backward selection method based on the choice of significant variables at bivariate analysis for model screening. After having defined the starting model, we assessed, by backward elimination, which confounding factor should remain in the model. We first looked to see if the least significant variable was a confounding factor by dropping it and refitting the model. We then assessed whether the odds-ratio (OR) changed by >10% compared with the OR of the starting model. We also checked whether precision was gained by comparing 95% CIs. If the ORs changed by >10%, the variables were considered as confounding factors and remained in what became the best final model. If the variables were not confounding factors, they were removed from the model and the same procedures were reapplied until the best final model was found [19,20]. Good fits of the models were assessed using the Hosmer–Lemeshow goodness of fit test [21]. For all models, we checked for any potential collinearity problems between the variables. None of the models used had variables with a condition index >20 or variance decomposition proportions >0.50. All analyses were implemented using SAS software, version 8.02 (SAS Institute, Inc., Cary, NC).

Results

Between 1 January 1 and 31 December 1999, 1634 eligible patients with a principal or secondary diagnosis of heart failure were discharged from the three Swiss university hospitals. We excluded 481 (29.4%) of these patients from the analysis for one or more of the following reasons: 31 (1.9%) patient records contained no information on discharge status, 134 (8.2%) patients transferred to another acute-care hospital, four (0.2%) were discharged in 1998, six (0.4%) were discharged against medical advice, and 306 (18.7%) experienced secondary heart failure. Among this group, 111 were excluded because of aortic stenosis, nine for mitral stenosis, 30 for thyrotoxicosis, one for thiamine deficiency, five for amyloidosis, 31 for renal insufficiency, 107 for acute myocardial infarction, and 30 for COPD requiring home oxygen. Additionally, 98 patients who died at the hospital were excluded further in the analysis involving readmissions.

Patient characteristics

There were 1153 patients with heart failure available for the analysis. The mean age of patients was 75.3 years [standard deviation (SD) 12.7] and 45.7% were female. A history of previous heart failure was noted for 56.7%, prior myocardial infarction for 32.7%, COPD or bronchitis for 20.4%, hypertension for 60.1%, diabetes for 23.1%, and 15.4% were current smokers. At admission, the following symptoms and findings were observed: 23.8% of patients suffered from heart failure for 56.7%, prior myocardial infarction for 32.7%, COPD or bronchitis for 20.4%, hypertension for 60.1%, diabetes for 23.1%, and 15.4% were current smokers.

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Finally, we performed a multivariate analysis using logistic regression. Given the small sample sizes and the large number of confounding factors, we used a priori backward selection method based on the choice of significant variables at bivariate analysis for model screening. After having defined the starting model, we assessed, by backward elimination, which confounding factor should remain in the model. We first looked to see if the least significant variable was a confounding factor by dropping it and refitting the model. We then assessed whether the odds-ratio (OR) changed by >10% compared with the OR of the starting model. We also checked whether precision was gained by comparing 95% CIs. If the ORs changed by >10%, the variables were considered as confounding factors and remained in what became the best final model. If the variables were not confounding factors, they were removed from the model and the same procedures were reapplied until the best final model was found [19,20]. Good fits of the models were assessed using the Hosmer–Lemeshow goodness of fit test [21]. For all models, we checked for any potential collinearity problems between the variables. None of the models used had variables with a condition index >20 or variance decomposition proportions >0.50. All analyses were implemented using SAS software, version 8.02 (SAS Institute, Inc., Cary, NC).
by chest X-ray. A cardiologist had been consulted by 54.1% of patients. The median length of stay was 10 days. Discharge counseling was documented in the medical charts of 3.1% of patients for low sodium-diet, 4.0% for daily weight monitoring, and 7.4% for smoking cessation.

**Determination of VF**

Among the 1153 eligible patients, 790 (68.5%) had VF determined. Among those, 478 (60.5%) had LVSD and 312 (39.5%) had preserved systolic function. The determination of VF was documented in a current EF for 547 (69.2%) patients, and depended on a narrative statement in their medical chart for 243 (30.8%).

Table 1 presents demographic characteristics, symptoms, and findings at admission, as well as risk factors for patients with heart failure by determination of VF. The mean (SD) age of patients who had their VF determined was 72.2 (12.5) years ($P < 0.0001$). Only 47.3% of patients >80 years of age had their VF determined, but 75.0% of male patients had their VF measured ($P < 0.0001$). Risk factors statistically associated with VF were previous myocardial infarction (82.4%; $P < 0.0001$), diabetes mellitus (76.1%; $P = 0.007$), and smoking (80.0%; $P = 0.0009$). Patients with the following symptoms and findings at admission had a statistically significant association with the assessment of the VF: PND, DOE, orthopnea, pulmonary rales, S3-gallop, or JVD.

Among 614 patients who saw a cardiologist during their hospital stay, 597 (97.2%) had VF measured ($P < 0.0001$). VF also was determined for 93.9% of patients who had counseling for low-salt diet ($P = 0.009$) and for 73.9% ($P = 0.002$) of patients who were already receiving ACEI on admission. Similarly, 79.4% of patients on anticoagulants ($P < 0.001$), 86.5% on β-blockers ($P < 0.0001$), and 86.6% on spironolactone ($P < 0.0001$) had VF measured. The mean (SD) length of stay was 14.6 days (15.6) for patients who had their VF measured ($P = 0.031$) (Table 2).

**ACEI use in patients with LVSD**

Among the 370 patients discharged with LVSD and no contraindication to ACEI, 199 (53.8%) were prescribed target-dose ACEI use in patients with LVSD.
ACEI or ARB at discharge, 119 (32.2%) received ACEI at discharge. Prescription of ACEI included Enalapril (81.6%), Captopril (7.9%), Lisinopril (5.8%), Perindopril (2.1%), Quinapril (1.0%), Ramipril (0.7%), Benazapril (0.3%), Fosinopril (0.3%), and Cilazapril (0.3%). Furthermore, 8.1% of the patients received calcium-blockers. With the exception of patients with previous history of heart failure, hypertension, diabetes mellitus, smoking, symptoms of PND, DOE, orthopnea, and physical findings of leg edema and pulmonary rales, no patient characteristics were associated with ACEI dosing. Patients who received ACEI on admission were more likely to be on target-dose ACEI at discharge ($P < 0.0001$). Similar findings were observed for β-blockers ($P = 0.007$), calcium-blockers ($P = 0.003$), digoxin ($P = 0.022$), diuretics ($P < 0.0001$), and spironolactone ($P = 0.006$). The mean length of stay was statistically significantly shorter in the target-dose ACEI group compared with the less than target and ACEI not-prescribed groups ($P = 0.004$) (Table 4).

**Table 2** Discharge characteristics of patients with heart failure by determination of ventricular function (VF; $n = 1153$)

<table>
<thead>
<tr>
<th>Discharge characteristic</th>
<th>Determination of VF</th>
<th>$P$-value (VF determined versus not determined)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Patients admitted with heart failure</td>
<td>Number (%) of patients who had VF determined [$n = 790 (68.5%)$]</td>
</tr>
<tr>
<td>Low-sodium diet ($n = 1078$)</td>
<td>33</td>
<td>31 (93.9)</td>
</tr>
<tr>
<td>Daily weight ($n = 1080$)</td>
<td>43</td>
<td>35 (81.4)</td>
</tr>
<tr>
<td>Smoking cessation ($n = 148$)</td>
<td>11</td>
<td>11 (100.0)</td>
</tr>
<tr>
<td>ACEI on admission ($n = 1071$)</td>
<td>440</td>
<td>325 (73.9)</td>
</tr>
<tr>
<td>Discharge medications ($n = 1070$)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticoagulants</td>
<td>316</td>
<td>251 (79.4)</td>
</tr>
<tr>
<td>β-blocker</td>
<td>148</td>
<td>128 (86.5)</td>
</tr>
<tr>
<td>Calcium blocker</td>
<td>146</td>
<td>102 (69.9)</td>
</tr>
<tr>
<td>Digoxin</td>
<td>338</td>
<td>231 (68.3)</td>
</tr>
<tr>
<td>Diuretics</td>
<td>657</td>
<td>462 (70.3)</td>
</tr>
<tr>
<td>Nitrates</td>
<td>317</td>
<td>214 (67.5)</td>
</tr>
<tr>
<td>Angiotensin receptor blocker</td>
<td>89</td>
<td>72 (80.9)</td>
</tr>
<tr>
<td>Spironolactone</td>
<td>127</td>
<td>110 (86.6)</td>
</tr>
<tr>
<td>Mean (SD) length of stay (days) ($n = 1153$)</td>
<td>14.0 (15.3)</td>
<td>14.6 (15.6)</td>
</tr>
</tbody>
</table>

ACEI, angiotensin converting enzyme inhibitor; SD, standard deviation.

ACEI or ARB at discharge, 119 (32.2%) received ACEI at less than target dose, and 52 (14.1%) received no ACEI at discharge. Prescription of ACEI included Enalapril (81.6%), Captopril (7.9%), Lisinopril (5.8%), Perindopril (2.1%), Quinapril (1.0%), Ramipril (0.7%), Benazapril (0.3%), Fosinopril (0.3%), and Cilazapril (0.3%). Furthermore, 8.1% of the patients received calcium-blockers. With the exception of patients with previous history of heart failure, hypertension, diabetes mellitus, smoking, symptoms of PND, DOE, orthopnea, and physical findings of leg edema and pulmonary rales, no patient characteristics were associated with ACEI dosing. Patients who received ACEI on admission were more likely to be on target-dose ACEI at discharge ($P < 0.0001$). Similar findings were observed for β-blockers ($P = 0.007$), calcium-blockers ($P = 0.003$), digoxin ($P = 0.022$), diuretics ($P < 0.0001$), and spironolactone ($P = 0.006$). The mean length of stay was statistically significantly shorter in the target-dose ACEI group compared with the less than target and ACEI not-prescribed groups ($P = 0.004$) (Table 4).

**Association between process and outcomes**

Among 1153 eligible patients hospitalized with heart failure, 98 (8.5%) died at the hospital. Among 1055 heart failure patients who survived their hospital stay, 139 were readmitted within 30 days to the same hospital (13.2%). Table 5 illustrates the association between process and outcome indicators. Among patients who had their VF determined, 7.2% died, and among those who did not, 11.3% died ($P = 0.021$). The adjusted OR was 1.74 (95% CI 1.06–2.84). Note that all analyses concerning readmissions were performed after the exclusion of patients who died during their hospital stay. Among patients who had VF determined, 14.5% were readmitted within 30 days, and among those who didn’t, 10.3% ($P = 0.063$) were readmitted within 30 days. In the multivariate analysis, the corresponding adjusted OR for readmissions after 30 days was 0.89 (95% CI 0.28–2.84) for the ACEI not-prescribed group and 1.17 (0.56–2.43) for the less than target group, using the target-dose group as a reference. Among patients with LVSD and no contraindication to ACEI, 9.6% of those prescribed no ACEI, 16.8% of those who received ACEI at less than target dose, and 13.6% of those receiving ACEI at target dose were readmitted within 30 days ($P = 0.442$). In the multivariate analysis, the corresponding OR for readmissions was 0.89 (95% CI 0.28–2.84) for the ACEI not-prescribed group and 1.17 (0.56–2.43) for the less than target group, using the target-dose group as a reference. Among patients with LVSD and no contraindication to β-blockers, 12.3% were readmitted within 30 days, and among those with LVSD who didn’t receive a β-blocker, 13.8% ($P = 0.840$) were readmitted within 30 days. The corresponding adjusted OR for readmissions was 1.22 (95% CI 0.47–3.18). Finally, among patients with atrial fibrillation and no contraindication to anticoagulants, 13.0% of those who received anticoagulants and 7.5% of those who didn’t were readmitted ($P = 0.260$). The adjusted OR was not statistically significant (Table 5).

**Discussion**

Our finding that hospital mortality was 8.5% among heart failure patients hospitalized in three Swiss academic medical centers is similar to that found in previous studies. In one
In an earlier study, the average in-hospital patient mortality in all Ohio hospitals from 1992–1993 was 6.3% [23]. In another study conducted in Ohio among 30 hospitals participating in the Cleveland Health Quality Choice, the crude hospital mortality rate for heart failure was 6.3% [23].

We found that crude readmission rates were 30% among heart failure patients hospitalized in Swiss university hospitals—higher than the results found by Thomas and Holloway for 31-day readmissions among 18 hospitals in Michigan (21%) [24]. In many studies, readmissions were measured in alternate time frames. In particular, a study implemented in Connecticut among Medicare beneficiaries found that 44% of patients were readmitted within 6 months [25]. In another study, the risk of readmission within 90 days varied between 29 and 42% [26]. In an earlier study among patients with LVSD from five US states, we found that the rate of readmission within 21 months was 70%, showing the vulnerability of patients to recurrent illness and their burden of disease [15].

Our main finding that patients with VF not determined with results from a previous study implemented in Chicago between 1992 and 1993 [27]. However, most studies reported mortality after hospital discharge. Several studies have shown improved survival to be associated with compliance with evidence-based guidelines for the management and treatment of heart failure. In particular, an overview of 32 randomized trials on the effect of ACEI on mortality and morbidity in patients with heart failure including 7105 patients showed that treatment with ACEI reduces the risk of death by 30% [13]. A more recent systematic overview included new randomized control trials involving 12763 patients with heart failure or left ventricular dysfunction, and found a slight decrease in mortality risk if patients were treated with ACEI [28]. In a study implemented among 2943 Medicare beneficiaries hospitalized for heart failure in 69 community hospitals in five US states, the adjusted hazard ratio for death was 1.63 (95% CI 1.02–2.60) for patients who were not prescribed ACEI at discharge, and 1.30 (95% CI 0.86–1.97) for those who were prescribed ACEI at less than the recommended dose compared with patients receiving target-dose ACEI [14]. Another recent
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study showed a similar pattern: patients who received the target dose of ACEI were associated with significantly lower adjusted 1-year mortality compared with those who received a low dose of ACEI [29].

Table 4 Discharge characteristics of patients with LVSD by ACEI treatment (n = 370)

<table>
<thead>
<tr>
<th>Discharge characteristic</th>
<th>ACEI dosage</th>
<th>Patients with LVSD</th>
<th>Target dose ACEI or ARB (53.8%, n (%))</th>
<th>Less than target-dose ACEI (32.2%, n (%))</th>
<th>ACEI not prescribed (14.1%, n (%))</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low sodium diet (n = 366)</td>
<td>18</td>
<td>12 (66.7)</td>
<td>6 (33.3)</td>
<td>0 (0.0)</td>
<td>0.192</td>
<td></td>
</tr>
<tr>
<td>Daily weight (n = 369)</td>
<td>17</td>
<td>8 (47.1)</td>
<td>9 (52.9)</td>
<td>0 (0.0)</td>
<td>0.077</td>
<td></td>
</tr>
<tr>
<td>Smoking cessation (n = 61)</td>
<td>6</td>
<td>3 (50.0)</td>
<td>2 (33.3)</td>
<td>1 (16.7)</td>
<td>0.743</td>
<td></td>
</tr>
<tr>
<td>ACEI on admission (n = 342)</td>
<td>179</td>
<td>112 (62.6)</td>
<td>59 (33.0)</td>
<td>8 (4.5)</td>
<td>&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Discharge medications (n = 369)

- **Anticoagulants**: 153 (51.6%)
- **β-blocker**: 64 (71.9%)
- **Calcium blocker**: 37 (67.6%)
- **Digoxin**: 140 (56.4%)
- **Diuretics**: 262 (63.7%)
- **Nitrates**: 116 (65.3%)
- **Spironolactone**: 76 (67.1%)

**Mean (SD) length of stay (days)**: 13.0 (10.6)

LVSD, left ventricular systolic dysfunction; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blockers.

Table 5 Bivariate and multivariate analysis: association between process and outcome indicators (n = 1153)

<table>
<thead>
<tr>
<th>Process indicators</th>
<th>Crude RR (95% CI)</th>
<th>P-value</th>
<th>Adjusted OR (95% CI)</th>
<th>P-value</th>
<th>Crude RR (95% CI)</th>
<th>P-value</th>
<th>Adjusted OR (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular function not determined</td>
<td>1.57 (1.07–2.29)</td>
<td>0.021</td>
<td>1.741 (1.06–2.84)</td>
<td>0.028</td>
<td>0.71 (0.49–1.02)</td>
<td>0.063</td>
<td>0.752 (0.47–1.18)</td>
<td>0.209</td>
</tr>
<tr>
<td>ACEI by dose category in patients with LVSD (n = 370)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No ACEI</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.71 (0.29–1.75)</td>
<td>0.838</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than target dose of ACEI</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1.24 (0.73–2.11)</td>
<td>0.673</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target dose of ACEI or ARB</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1.00 (0.56–2.43)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No β-blockers in patients with LVSD (n = 297)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>1.12 (0.52–2.84)</td>
<td>0.647</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No anticoagulants in patients with atrial fibrillation (n = 211)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>0.58 (0.24–1.40)</td>
<td>0.354</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NA, not applicable—relates only to patients discharged alive; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; OR, odds ratio; RR, risk ratio; COPD, chronic obstructive pulmonary disease.

1Controlling for hospitals, hypertension, COPD, creatinine, and potassium.

2Controlling for hospitals, diabetes mellitus, COPD, and smoking.

3Controlling for hospitals and the ejection fraction.

4Controlling for hospitals.

In our data, we did not find any correlation between heart failure patients with VF determined, treated at target-dose ACEI, or treated with β-blockers or anticoagulants in case of atrial fibrillation. We also found a decrease in readmission...
after 30 days. However, several studies have shown this type of relationship previously. One study implemented in five US states among Medicare beneficiaries demonstrated that patients not prescribed ACEI at discharge had an adjusted rate ratio of readmissions (RR) of 1.74 (95% CI 1.22–2.48), while patients prescribed ACEI at less than the recommended dose had a RR of 1.24 (95% CI 0.91–1.69) compared with patients receiving target-dose ACEI [15]. However, two manuscripts reporting a study implemented in an academic medical center in the Chicago metropolitan area concluded that patients who had an assessment of VF had statistically significantly higher rates of readmission [27]. Furthermore, patients who received ACEI at discharge were less likely to be readmitted [30]. Similar results were also found in a multi-center randomized control trial implemented among heart failure patients with New York Heart Association class II–IV and an EF of <30% [31]. The authors observed a 24% decreased risk of hospitalization for heart failure and a 13% decreased risk of hospitalization for any cause between the low- and high-dose Lisinopril groups. Another study showed similar patterns [32]. A recent systematic overview of five randomized control trials of ACEI use in 12,763 patients with heart failure showed that treatment with ACEI reduces the risk of readmission for heart failure [28].

Even if process quality indicators for heart failure patients were not associated with crude readmissions in our data, there is considerable evidence that recommendations documented in clinical guidelines for the management and treatment of heart failure patients improve survival [1,4–8]. Methods of measuring process quality indicators for heart failure patients have clearly been established [9,10,12,14,15,33,34]. Measuring outcomes, specifically in readmissions, is more difficult and more controversial. Some authors found associations between process of care and readmissions. Ashton et al., in a recent meta-analysis, tried to investigate the controversial issue of the validity of early readmission as a quality indicator. They found that the odds of readmission increased 55 times for low-quality care compared with higher quality care [35]. In a recent study implemented in Switzerland, authors showed that unplanned readmissions of patients with heart failure were not associated with hospital quality of care, but were strongly related to patients’ clinical and demographic characteristics [36]. These results emphasize that a consistent link between the quality of care and early readmission has not clearly been established. Specifically, there is a lack of sound risk adjustment methods. This has triggered the Heart Failure Working Group from the American Heart Association/American College of Cardiology Scientific Forum of Care and Outcome Research in Cardio-Vascular Disease and Stroke to recommend not using readmissions as an outcome measure for comparing hospitals at this stage [33].

Several limitations may have biased our results and need to be mentioned. Firstly, hospital participation was voluntary. This creates the potential for selection bias, since the pattern of prescription could differ considerably between these voluntary hospitals and other hospitals, making the generalization of results questionable. Secondly, for readmissions, we assumed that all patients continued taking the same type and dose of treatment as prescribed at index discharge, and that patient compliance was optimal. However, not all patients were discharged from the hospital at ACEI target doses since there is a necessary period of dose titration (around 2–3 weeks) until the target ACEI dose is established. Therefore, this analysis could introduce a potential misclassification bias, since people who ultimately receive target dose levels of ACEI will remain in the subtarget group in this analysis.

Other limitations are specific to the Swiss health care system. Providing administrative discharge data has been mandatory in Switzerland since 1998. Many practical problems remain because each hospital has its own way of collecting data. The quality of the data differs between institutions and still is not optimal, although it is improving each year. In particular, in one hospital we were able to select only 234 eligible patients with heart failure ICD-10 codes from the administrative data set, which represents about one-third of all potential cases. This introduces selection bias. Furthermore, each hospital has a different structural organization. In two hospitals, we had access to the entire medical charts, but in the third one, only the electronic medical charts were available for chart abstraction. Furthermore, in each of the three hospitals, different people with different educational backgrounds did the chart abstraction, which could lead to misclassification bias. Finally, it is possible that people who died early during hospitalization did not have the opportunity to have their VF determined, raising the possibility that the association between VF determination and mortality was inflated. Several lines of indirect evidence argue against this possibility. Firstly, the length of stay of deceased patients was actually longer than that of other patients, so that on average, they actually had a longer time in which to obtain the test. Secondly, the association with mortality was similar when we looked only at VF determination before admission. Thirdly, the association remained similar, even after controlling for length of stay in logistic regression models (OR 1.59; 95% CI 0.95–2.66), thus providing evidence that the association was real.

In conclusion, our results suggest that among patients with heart failure, hospital mortality was associated with the determination of the VF, and that readmissions were not associated with process quality of care indicators. However, appropriate use and interpretation of readmissions is a difficult task. In particular, numerous limitations exist with respect to all currently available risk adjustment methods. The use of routinely collected data to monitor quality of care (administrative data, medical records) in heart failure patients was feasible in these three hospitals, but such an approach is limited by the nature and quality of the data. Finally, even if we found controversial results regarding readmissions, it is well known that compliance with recommendations of evidence-based guidelines for the management and treatment of heart failure patients confers benefits. Clinicians should consider following recommended guidelines when treating these patients.

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