International Journal for Quality in Health Care 2003; **Volume 15, Number 5**: pp. 413–421 10.1093/intqhc/mzg055

Readmissions and the quality of care in patients hospitalized with heart failure

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Abstract

Objectives. Clinical practice guidelines based on the results of randomized clinical trials recommend that patients with heart failure due to left ventricular systolic dysfunction (LVSD) be treated with angiotensin-converting enzyme inhibitors (ACEI) at doses shown to reduce mortality and readmission. This study examined the relationship between ACEI use at discharge and readmission among patients with heart failure due to LVSD.

Methods and results. Data were abstracted from the medical records of 2943 randomly selected patients hospitalized for heart failure in 50 hospitals. The outcome of interest was the number of readmissions occurring up to 21 months after discharge. Six-hundred and eleven patients were eligible for analysis. Compared with patients discharged at a recommended ACEI dose, patients not prescribed an ACEI at discharge had an adjusted rate ratio of readmission (RR) of 1.74 [95% confidence interval (CI) 1.22–2.48], while patients prescribed an ACEI at less than a recommended dose had an RR of 1.24 (95% CI 0.91–1.69) ($P = 0.005$ for the trend).

Conclusion. Our results show that ACEI use at discharge in patients with LVSD is associated with decreased rate of readmission. These findings suggest that compliance with the ACEI prescribing recommendations listed in clinical practice guidelines for patients with heart failure due to LVSD confers benefit.

Keywords: angiotensin-converting enzyme inhibitors, heart failure, left ventricular systolic dysfunction, outcome assessment, quality of health care, readmissions

Heart failure accounted for >605 000 (6.5%) of the ~9.4 million total hospital discharges among Medicare beneficiaries aged ≥65 years in 1995 [1]. The readmission rates within 2 and 30 days of discharge with heart failure as the primary diagnosis were 21.4 per 1000 and 208.4 per 1000, respectively [1]. Heart failure clearly imposes an extensive disease burden upon this population.

Clinical practice guidelines recommend that patients with heart failure due to left ventricular systolic dysfunction (LVSD) be treated with angiotensin-converting enzyme inhibitors (ACEIs) at doses shown to reduce mortality in randomized clinical trials [2–5]. An overview of 30 randomized clinical trials indicated that treatment with ACEI is effective in reducing the risk of mortality and hospitalization (a combined endpoint) for heart failure [6]. However, studies have demonstrated that clinicians often fail to prescribe ACEI and that a large percentage of their patients are not prescribed ACEI at the proper dose [7–12]. We and others have shown that failure to adhere to guidelines for ACEI prescription is associated with higher mortality among patients with heart failure due to LVSD in community hospitals [13,14]. The purpose of this study was to examine the relationship between ACEI use at discharge and hospital readmission rates among Medicare patients treated in community hospitals for heart failure due to LVSD. We also aimed to explore whether results from randomized controlled trials can be generalized to community hospitals.

Methods

Study design

This was a retrospective cohort study of Medicare patients who were hospitalized for heart failure due to LVSD between 30 June 1995 and 30 September 1996. Follow-up for each patient began on the date of discharge of the index hospitalization and continued for 21 months.

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Study population

The study population was randomly selected from 50 community hospitals in five US states (Colorado, Connecticut, Georgia, Oklahoma, and Virginia). Thirty-two hospitals out of 50 participated voluntarily in a quality improvement trial. Fifty participants within each hospital were randomly selected Medicare beneficiaries with a primary diagnosis of heart failure [International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes 428 inclusive]. One state used Diagnostic Related Group (DRG) code 127 (heart failure) to identify eligible patients. If <50 eligible patients had been discharged during the enrolment period, we evaluated all admissions for heart failure. Patients were excluded from the sample if the initial hospitalization was terminated against medical advice, if they had been transferred to another hospital (i.e. we would not obtain complete information about the hospital stay and discharge), or if they died during the index hospitalization. Additional exclusion criteria included age <65 years (Medicare population), contraindication to ACEI treatment noted in the hospital chart, incomplete charts, secondary causes for heart failure (aortic stenosis, mitral stenosis, acute myocardial infarction, cor pulmonale, chronic obstructive pulmonary disease treated with oxygen, thiamine deficiency, amyloidosis, thyrotoxicosis), heart failure with preserved systolic function, or no documentation regarding ventricular function.

Data

The data were abstracted from copies of hospital charts by trained nurses and/or medical record specialists. Information on patient and hospital characteristics, clinical and laboratory results, and history and physical findings were abstracted from the medical charts of the index hospitalization. Initial and subsequent admissions were identified using the Health Care Financing Administration MEDPRO file.

LVSD was defined as any measured ejection fraction ≤40% documented in the chart from a previous or the current hospitalization. If no information regarding ejection fraction was found in the chart, patients were classified as having LVSD if the narrative description of left ventricular function included systolic dysfunction, dilated cardiomyopathy, cardiomyopathy, and diffuse or global hypokinesis or ejection fraction (including mildly, moderately, or severely reduced).

ACEIs identified in the hospital charts by generic or trade name included benazepril, captopril, enalapril, fosinopril, lisinopril, quinapril, and ramipril. Three treatment groups were defined based on ACEI prescription levels: target dose, less than target dose, or no prescription at time of discharge. Target levels were defined as the dose found to reduce risk of death in patients with LVSD in controlled clinical trials (captopril 50 mg tid, enalapril 10 mg bid, lisinopril 20 mg qd, ramipril 5 mg bid) [15]. If clinical trial evidence was unavailable, target dose levels were based on the manufacturer's stated average doses (benazepril 20 mg qd, fosinopril 40 mg qd, and quinapril 10 mg bid) [16].

A Deyo modification of the Charlson comorbidity index was used to compute a severity of illness index for each patient [17]. The Charlson index is a weighted sum of selected comorbidities. Discharge conditions from the index hospitalization of each patient were used to compute the severity of illness.

Statistical analysis

The dependent variable (outcome) was the number of readmissions measured during seven distinct time periods (0–3 months, >3–6 months, >6–9 months, >9–12 months, >12–15 months, >15–18 months, and >18–21 months after discharge from the index hospitalization). The primary exposure variable was treatment group at time of index hospital discharge (ACEI at target dose [reference], ACEI at suboptimal dose, and no treatment with ACEI). Other variables included in the analysis as potential confounders were age, sex, race, the Charlson comorbidity index, and a history of heart failure, diabetes mellitus, hypertension, prior myocardial infarction, chronic obstructive pulmonary disease (COPD)/bronchitis, or smoking. Additional covariates included findings of paroxysmal nocturnal dyspnea (PND), dyspnea on exertion (DOE), orthopnea, leg edema, pulmonary rales, jugular venous dilatation (JVD), S3 gallop, ECG findings for atrial fibrillation, serum creatinine and potassium results, minimum ejection fraction, length of stay, and hospital.

Intention to treat analysis was employed for the primary exposure variable. For all time intervals, all patients were analyzed as belonging to the ACEI treatment group at time of index hospital discharge.

Patient characteristics at the index admission were tabulated. Bivariate analyses were employed to describe the relationship between patient characteristics and number of readmissions in each treatment group. In all bivariate analyses, the crude rates of readmission were calculated by dividing the number of readmissions by the total living person-time in days for each treatment group. Crude rate ratios were then estimated and chi-square values were used to test for significance. Life-test procedures and survival analysis using a Cox model were used to obtain Kaplan-Meier curves and to explore the relationship between the time to first readmission in each ACEI treatment group, respectively. The proportional hazard assumption was met in the Cox model [18].

A simple Poisson regression was used to calculate adjusted rate ratios for the first 3 months. Furthermore, a multivariate correlated data analysis using Poisson regression and generalized estimating equations (GEE) considering fixed effects was performed [19–21]. This method accounts for the potential correlation of repeated admissions for the same patient. Because patients drawn randomly from the same hospital may be more similar to one another in terms of exposure and outcome status, we nested the patients within the index hospital.

In all analyses we used the date of death for censoring patients who died during the follow-up period, and $P < 0.05$ as a cut-off value for significance. We assessed interaction, confounding, and model fit [22]. A hierarchically well formulated (HWF) model was formed with all covariates (previously described) entered into the model, as well as potential interaction terms involving treatment group and the other

covariates. Deviance values were used to assess the model fit [23]. Analyses were implemented with the SAS software (SAS Institute Inc., Cary, NC, USA).

Results

There were 2943 eligible patients with a principal diagnosis of heart failure at discharge from the participating hospitals identified between 30 June 1995 and 30 September 1996. We excluded 2332 (79.2%) of these patients from the analysis for the following reasons: 267 (11.4%) were ineligible after initial chart review because of an incomplete chart; 599 (25.7%) had secondary causes for heart failure; 584 (25.0%) did not have documented ventricular function; and 659 (28.3%) had left ventricular diastolic dysfunction. Further, we excluded from the analysis all patients who were aged <65 years, who died during hospitalization, who were transferred to another hospital, who had an incomplete chart, and who had a stated contraindication to ACEI noted in the chart [a total of 223 (9.6%)].

Patient characteristics

There were 611 patients with LVSD remaining for analysis. At discharge 128 (21%) were not prescribed ACE inhibitors, 367 (60%) were prescribed ACEI at levels less than target dose, and 116 (19%) were prescribed target dose of ACEI. The determination of LVSD was documented by a previous or current ejection fraction for 509 (83%) patients and depended on a narrative summary for 102 (17%) patients. The mean age of patients was 77.5 (standard deviation 7.0) years; 43% were female and 81% were white. A history of previous heart failure was noted for 77%, a prior myocardial infarction for 50%, COPD or bronchitis for 36%, hypertension for 67%, and diabetes for 41% of patients. Eleven percent were current smokers. At admission, patients had the following symptoms and findings: 36% PND, 40% DOE, 42% orthopnea, 67% leg edema, 85% pulmonary rales, 30% S3 gallop, 50% JVD, and 25% atrial fibrillation. The mean minimum value of the current or previous ejection fraction was 26%. The median Charlson comorbidity index was 2. The median serum potassium and creatinine values were 4.2 mmol/l and 1.2 mg/dl, respectively. The median length of stay was 5 days. A total of 256 (42%) patients died during the follow-up period. Patient characteristics by ACEI group have already been published in this journal [13].

Hospital readmissions

During the 21-month follow-up period, 425 (70%) patients had at least one readmission. The number of readmissions per patient varied from none to 18 (with a median of one). The associations between patient characteristics and hospital readmission rates by ACEI group (target dose ACEI, less than target, and ACEI not prescribed) are shown in Tables 1 and 2. Patients not prescribed ACEI at discharge with prior myocardial infarction and hypertension had significantly higher rates of readmission (Table 1). Opposite patterns were observed for patients with history of heart failure, diabetes, and who currently smoked. A statistically significant increase in admission rates was also observed with increases in both the Charlson comorbidity index and in serum creatinine levels for patients not prescribed ACEI (Table 2).

Association between ACEI use and readmission

First readmission. Among the patients with LVSD who were prescribed ACEI at target dose, 71 (61%) had a first readmission; among those who were prescribed ACEI at lower than target dose, 258 (70%) had a first readmission; and among those patients who did not receive ACEI at discharge, 96 (75%) had a first readmission ($P = 0.041$ for the overall association; $P = 0.021$ between 'at target dose ACEI' and 'less than target'; and $P = 0.310$ between 'less than target' and 'no ACEI'). Patients treated according to clinical guidelines had a longer time to first readmission. The median time before being readmitted was 258 days for patients who were prescribed ACEI at target dose, 212 for patients prescribed less than target dose, and 138 days for patients who did not receive ACEI at discharge. Figure 1 shows the Kaplan-Meier survival curve to first readmission by level of ACEI dose. The log-rank test was statistically significant ($P = 0.009$). The adjusted hazard ratio [95% confidence interval (CI)] for the time to the first readmission was 1.25 (0.95–1.64) for lower than target dose ACEI, and 1.86 (1.34–2.60) when ACEI was not prescribed (target dose = reference).

Frequency of readmission. Table 3 shows the rate ratios for the 3-month time period and for the entire follow-up period. There were 1119 readmissions (mean 1.8 per patient) for the entire 21-month follow up period. The mean number of readmissions per patient was 1.53 (177/116) for patients who were prescribed target doses of ACEI at the index discharge. The mean was 1.83 (673/367) for patients prescribed ACEI at lower than target dose, and 2.10 (269/128) for patients who were not prescribed ACE inhibitors. Patients not prescribed ACEI at discharge had a 70% increase in readmission rates [(RR) 1.70; 95% CI 1.40–2.07], and patients at less than target dose a 31% increase (RR 1.31; 95% CI 1.11–1.56) compared with patients prescribed the drug at target doses.

The Cox model presented under first readmission takes into account only the first readmission and ignores that many of the patients experienced multiple readmissions. We therefore performed a second analysis. Using Poisson regression and GEE procedures, we were able to incorporate the frequency of readmission for each patient and to account for the potential correlation of the data. In the Poisson multivariate analysis, the adjusted rate ratio (95% CI) for the first 3-month period was 1.31 (0.92–1.87) for lower than target dose ACEI, and 1.69 (1.13–2.54) when ACEI was not prescribed (target dose = reference). Factors significantly associated with readmission during the first 3 months included sex, history of heart failure, hypertension, and length of stay. Finally, when we accounted for the potential correlation of the data using

Table I Demographic characteristics, and symptoms and findings at admission of patients with left ventricular systolic dysfunction in relation to readmissions by level of ACEI treatment ($n = 611$)

Patients' characteristics	Crude rate ratio and 95% confidence interval for readmissions ACEI dosage			
	n	Target dose	Less than target	Not prescribed
Age quartiles				
Q1: 64.5–72.1 years	152	Ref.	Ref.	Ref.
Q2: 72.1–77.2 years	153	0.84 (0.56–1.25)	1.13 (0.91–1.41)	1.07 (0.77–1.50)
Q3: 77.2–82.5 years	153	0.61 (0.38–0.97)	0.96 (0.77–1.21)	0.87 (0.61–1.26)
Q4: >82.5 years	153	0.78 (0.51–1.18)	1.25 (0.99–1.56)	0.79 (0.54–1.15)
Sex				
Female	264	Ref.	Ref.	Ref.
Male	347	0.92 (0.67–1.24)	0.84 (0.72–0.97)	1.14 (0.89–1.46)
Race				
Non-white	116	Ref.	Ref.	Ref.
White	493	0.78 (0.55–1.11)	1.02 (0.85–1.24)	1.21 (0.85–1.75)
History of heart failure				
No	142	Ref.	Ref.	Ref.
Yes	469	2.43 (1.57–3.90)	1.84 (1.51–2.26)	1.75 (1.27–2.45)
Prior myocardial infarction				
No	303	Ref.	Ref.	Ref.
Yes	308	1.27 (0.93–1.71)	1.06 (0.91–1.24)	1.33 (1.04–1.71)
COPD, bronchitis				
No	390	Ref.	Ref.	Ref.
Yes	221	0.92 (0.65–1.28)	0.99 (0.84–1.16)	0.94 (0.71–1.22)
Hypertension				
No	200	Ref.	Ref.	Ref.
Yes	411	0.94 (0.66–1.37)	1.11 (0.94–1.31)	1.42 (1.09–1.86)
Diabetes				
No	363	Ref.	Ref.	Ref.
Yes	248	1.88 (1.38–2.56)	1.22 (1.04–1.42)	1.62 (1.27–2.07)
Current smoker				
No	544	Ref.	Ref.	Ref.
Yes	67	0.76 (0.46–1.21)	0.81 (0.62–1.04)	0.52 (0.29–0.88)
Symptoms and findings				
Paroxystal nocturnal dyspnea				
No	394	Ref.	Ref.	Ref.
Yes	217	1.18 (0.87–1.60)	0.87 (0.74–1.02)	0.81 (0.60–1.08)

Table I *continued*

Patients' characteristics	Crude rate ratio and 95% confidence interval for readmissions ACEI dosage			
	n	Target dose	Less than target	Not prescribed
Dyspnea on exertion				
No	365	Ref.	Ref.	Ref.
yes	246	1.20 (0.88–1.64)	0.80 (0.68–0.93)	0.91 (0.70–1.17)
Orthopnea				
No	356	Ref.	Ref.	Ref.
Yes	255	0.93 (0.68–1.26)	0.76 (0.65–0.89)	1.09 (0.85–1.40)
Leg edema				
No	204	Ref.	Ref.	Ref.
Yes	407	1.07 (0.76–1.52)	1.06 (0.90–1.24)	1.24 (0.95–1.65)
Pulmonary rales				
No	90	Ref.	Ref.	Ref.
Yes	521	0.64 (0.42–1.02)	0.79 (0.65–0.97)	0.95 (0.68–1.34)
S3 gallop				
No	425	Ref.	Ref.	Ref.
Yes	186	1.01 (0.74–1.36)	1.18 (1.00–1.38)	1.08 (0.81–1.42)
Jugular vein distension				
No	308	Ref.	Ref.	Ref.
Yes	303	1.11 (0.82–1.52)	1.36 (1.17–1.59)	1.18 (0.93–1.51)
Atrial fibrillation				
No	442	Ref.	Ref.	Ref.
Yes	145	0.92 (0.61–1.36)	0.94 (0.77–1.15)	0.98 (0.75–1.28)

ACEI, angiotensin-converting enzyme inhibitor; COPD, chronic obstructive pulmonary disease.

Table 2 Admission characteristics of patients with left ventricular systolic dysfunction in relation to readmissions by level of ACEI treatment, $n = 611$

Patients' characteristics	Crude rate ratio and 95% confidence interval for readmissions ACEI dosage			
	n	Target dose	Less than target	Not prescribed
Minimum ejection fraction				
≤20%	162	1.28 (0.84–1.97)	1.27 (1.01–1.60)	1.33 (0.96–1.87)
21–30%	196	1.11 (0.74–1.69)	1.36 (1.09–1.71)	0.75 (0.54–1.04)
31–40%	151	Ref.	Ref.	Ref.
Charlson comorbidity index				
1	187	Ref.	Ref.	Ref.
2	260	1.26 (0.88–1.84)	1.07 (0.89–1.29)	1.65 (1.17–2.35)
≤3	164	1.19 (0.74–1.90)	1.28 (1.05–1.57)	2.23 (1.57–3.22)
Potassium (mmol/l)				
≤4.0	255	Ref.	Ref.	Ref.
4.1–5.0	323	1.03 (0.76–1.41)	0.85 (0.72–0.99)	0.98 (0.76–1.27)
>5.0	28	1.54 (0.48–3.74)	0.92 (0.60–1.34)	0.85 (0.41–1.58)
Creatinine (mg%)				
≤1.0	189	Ref.	Ref.	Ref.
1.1–2.0	349	1.35 (0.96–1.93)	1.10 (0.93–1.31)	1.57 (1.16–2.16)
>2.0	68	1.37 (0.79–2.31)	1.40 (1.06–1.84)	2.10 (1.30–3.32)
Length of stay				
1–5 days	349	Ref.	Ref.	Ref.
≥6 days	262	1.39 (1.00–1.90)	1.26 (1.08–1.47)	0.89 (0.69–1.13)

ACEI, angiotensin-converting enzyme inhibitor.

Table 3 Readmissions at 3, 6, 12, and 21 months after discharge in patients with left ventricular systolic dysfunction by level of ACEI treatment: bivariate analysis, $n = 611$

	Crude rate ratio and 95% confidence interval for readmissions ACEI dosage		
	Target dose ($n = 116$)	Less than target ($n = 367$)	Not prescribed ($n = 128$)
Readmissions at			
3 months	1.00 (Ref.)	1.27 (0.93–1.77)	1.47 (1.02–2.15)
6 months	1.00 (Ref.)	1.18 (0.92–1.52)	1.49 (1.12–1.99)
12 months	1.00 (Ref.)	1.18 (0.98–1.44)	1.52 (1.22–1.91)
21 months	1.00 (Ref.)	1.31 (1.11–1.56)	1.70 (1.40–2.07)

ACEI, angiotensin-converting enzyme inhibitor.

GEE procedures, the adjusted RR for the entire 21-month follow-up period was 1.24 (95% CI 0.91–1.69) for less than target dose ACEI, and 1.74 (1.22–2.48) when ACEI was not prescribed (Table 4). The trend (treatment effect) was statistically significant ($P = 0.005$). Other factors significantly associated with readmission in these correlated data analyses included history of heart failure, diabetes, and elevated creatinine level. Using the deviance as a statistical tool, our final model demonstrated a good fit to the data (deviance/degrees of freedom = 1.0326). Table 5 provides comparative results between readmissions and our previous analysis on mortality [13].

Discussion

Although several evidence-based guidelines recommend ACEI prescription for patients such as those described above, our study showed substantial variation in treatment. For example, at discharge, 21% of the patients were not prescribed ACEI and only 19% were prescribed ACEI at target dose. This result is consistent with other studies that show a large proportion of patients are not prescribed ACEI when indicated or are prescribed ACEI at improper doses [7–12]. These results are particularly important in view of the substantial difference in the quality of medical care provided for Medicare patients [24]. In particular, in a previous study we found that failure to adhere to guidelines for ACEI prescription was related to higher mortality among heart failure patients [13]. Our study extends these findings to show increased morbidity and rehospitalization in heart failure patients where ACEI prescription fails to adhere to clinical guidelines.

In our study, 70% of patients were readmitted at least once within 21 months. This result is higher than reported in other studies. In particular, a study in Connecticut with a similar

Table 4 Readmissions in relation to ACEI dose for patients with left ventricular systolic dysfunction: multivariate analysis using Poisson regression and GEE procedures, $n = 611$

	Parameter estimate	Standard error	*P* value	Adjusted rate ratio	Lower 95% CI	Upper 95% CI
Intercept	−6.738	0.334	<0.001			
Target	Ref.	Ref.	Ref.	1.00	Ref.	Ref.
Less than target	0.214	0.158	0.173	1.24	0.91	1.69
ACEI not prescribed	0.555	0.181	0.002	1.74	1.22	2.48
Sex	0.178	0.114	0.117	1.20	0.96	1.49
History of heart failure	0.593	0.126	<0.001	1.81	1.41	2.32
Diabetes	0.344	0.113	0.002	1.41	1.13	1.76
Minimum ejection fraction	−0.009	0.006	0.137	0.99	0.98	1.00
Creatinine	0.185	0.075	0.013	1.20	1.04	1.39
Length of stay (continuous)	0.012	0.011	0.110	1.02	1.00	1.04

ACEI, angiotensin-converting enzyme inhibitor; CI, confidence interval; GEE, generalized estimating equations.

Table 5 Mortality and readmissions of patients with left ventricular systolic dysfunction by level of ACEI treatment, $n = 621$

	Mortality (12 months) [13], $n = 621$		Readmissions (21 months), $n = 611$	
	Crude risk (95% CI)	Adjusted hazard ratio (95% CI)	Crude rate ratio (95% CI)	Adjusted rate ratio (95% CI)
ACEI dose				
Target	1.00	1.00	1.00	1.00
Less than target	1.36 (0.95–1.92)	1.30 (0.86–1.97)	1.31 (1.11–1.56)	1.24 (0.91–1.69)
Not prescribed	1.69 (1.16–2.47)	1.63 (1.02–2.60)	1.70 (1.40–2.07)	1.74 (1.22–2.48)

ACEI, angiotensin-converting enzyme inhibitor; CI, confidence interval.

population of Medicare beneficiaries found that 44% were readmitted at 18 months [25]. In our study, 62% of patients had had at least one readmission at 18 months. We also found the same result for patients from Connecticut only. However, in the latter study all patients with heart failure were included; in our study only patients with LVSD were included. In another study, the 90-day risk of a first readmission varied between 29% and 42% [26].

Our study results show that patients with LVSD who receive no ACEI or who receive less than target doses of ACEI have a higher rate of readmission than those who receive target ACEI doses. These results are consistent with those from a multi-centered randomized controlled trial performed with 3164 patients with New York Heart Association II to IV heart failure and an ejection fraction ≤30% [27]. Patients were assigned either a low-dose (2.5–5.0 mg daily) or high-dose (32.5–35 mg daily) regimen of the ACE inhibitor lisinopril (ATLAS study). The authors observed a 13% decrease in the risk of hospitalization for any cause, and a 24% decrease of hospitalization for heart failure between the low- and the high-dose group. They concluded that target doses of ACEI should be prescribed to patients with heart failure due to LVSD to reduce readmissions [27]. Other studies have also demonstrated measurable effects on readmission for patients treated with ACE inhibitors [28,29]. A recent meta-analysis of five randomized, placebo-controlled trials of ACEI use in patients with heart failure or left ventricular dysfunction ($n = 12\,763$) convincingly showed that treatment with ACEI reduces the risk of death: [odds ratio (OR) 0.80; 95% CI 0.74–0.87] [30]. Furthermore, the same study showed that the risk of readmission for heart failure was also reduced by treatment with ACEI (OR 0.67; 95% CI 0.61–0.74). Therefore, prescription of ACEI for patients who suffer from heart failure due to LVSD could be considered an indicator of quality of care.

Our study has some limitations. Firstly, current national guidelines for heart failure treatment recommend the use of ACEI at target dose. However, individual patient factors may preclude following recommended guidelines. While we controlled for some of these factors (e.g. creatinine), we cannot exclude the possibility that other patient characteristics account for failure to treat according to guidelines. Secondly, we have assumed that all patients remained on the same treatment type and dose as prescribed at index discharge, and

that there was patient compliance. This assumption fails to account for a necessary period of dose titration to target levels (approximately 2–3 weeks). Therefore, we could have misclassified patients who actually received target levels of ACEI. Thirdly, the outcome of interest (number of readmissions) was collected from the medical record of each patient without taking into account the reason for readmission (ICD-9 codes were not available). Some of the readmissions could be unrelated to the disease of interest (e.g. trauma). A potential for overestimation of readmission rates in each treatment group is therefore created. Furthermore, if the readmissions not related to heart failure disease differ among treatment groups, a potential for bias is created. Fourthly, although we excluded patients with contraindications to ACEI documented in the chart (particularly hypotension), we did not have a measure of discharge systolic blood pressure. Some patients with severe heart failure and low blood pressure may have contraindication to ACEI, therefore are more prone to readmission. This is a factor that may have influenced our results and that we were not able to control for. Fifthly, it is possible that some heart failure readmissions that occurred in Veterans Affairs (VA) hospitals were missed [31]. Sixthly, it is possible that some patients hospitalized for symptoms due to heart failure, but labeled as some other condition at discharge, were not included in our analysis, which might have introduced a selection bias. Finally, hospital participation is on a voluntary basis. This may create a potential selection bias and limits the generalization of our results.

In conclusion, we observed a variation in treatment and in treatment effect. We found a steadily decreasing rate of readmission among patients treated with a target dose of ACEI compared with those receiving subtarget, and with those with no prescription for ACEIs. The trend of treatment effect was statistically significant even after adjusting for known and potential confounding factors. These results were observed during the first 3 months and after prolonged follow-up. The variation in ACEI use in our study shows a treatment effect in the first 3 months consistent with guideline recommendations. Furthermore, our results indicate that variations in ACEI prescription identify groups who will have different outcomes over prolonged follow-up, even after accounting for severity of illness. Our findings suggest that compliance with ACEI prescribing guidelines confers benefit to patients with heart failure due to LVSD in community hospitals. Clinicians should consider following the recommended guidelines when managing these patients.

Acknowledgements

The analyses upon which this publication is based were performed under the following contracts: (1) 500-96-704, entitled *Utilization and Quality Control Peer Review Organization for the State of Georgia*; (2) 500-99-P619, entitled *Utilization and Quality Control Peer Review Organization for the State of Oklahoma*; (3) 500-96-P538, entitled *Utilization and Quality Control Peer Review Organization for the Commonwealth of Virginia*; (4) 500-96-P549, entitled *Utilization and Quality Control Peer Review Organization for the State of Connecticut*; and (5) 500-96-P611, entitled *Utilization and Quality Control Peer Review Organization for the State of Colorado*, which were each sponsored by the Health Care Financing Administration, Department of Health and Human Services. The content of this publication does not necessarily reflect the views or policies of the Department of Health and Human Services, nor does mention of trade names, commercial products, or organizations imply endorsement by the US Government. The authors assume full responsibility for the accuracy and completeness of ideas presented. This article is a direct result of the Health Care Quality Improvement Program initiated by the Health Care Financing Administration, which has encouraged identification of quality improvement projects derived from analysis of patterns of care, and therefore required no special funding on the part of this contractor.

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Accepted for publication 9 April 2003