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ORIGINAL ARTICLE

Early Ambulation Among Hospitalized Heart Failure Patients Is Associated With Reduced Length of Stay and 30-Day Readmissions

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BACKGROUND: Early ambulation (EA) is associated with improved outcomes for mechanically ventilated and stroke patients. Whether the same association exists for patients hospitalized with acute heart failure is unknown. We sought to determine whether EA among patients hospitalized with heart failure is associated with length of stay, discharge disposition, 30-day post discharge readmissions, and mortality.

METHODS AND RESULTS: The study population included 369 hospitals and 285 653 patients with heart failure enrolled in the Get With The Guidelines-Heart Failure registry. We used multivariate logistic regression with generalized estimating equations at the hospital level to identify predictors of EA and determine the association between EA and outcomes. Sixty-five percent of patients ambulated by day 2 of the hospital admission. Patient-level predictors of EA included younger age, male sex, and hospitalization outside of the Northeast (P<0.01 for all). Hospital size and academic status were not predictive. Hospital-level analysis revealed that those hospitals with EA rates in the top 25% were less likely to have a long length of stay (defined as >4 days) compared with those in the bottom 25% (odds ratio, 0.83; confidence interval, 0.73–0.94; P=0.004). Among a subgroup of fee-for-service Medicare beneficiaries, we found that hospitals in the highest quartile of rates of EA demonstrated a statistically significant 24% lower 30-day readmission rates (P<0.0001). Both end points demonstrated a dose–response association and statistically significant P for trend test.

CONCLUSIONS: Multivariable-adjusted hospital-level analysis suggests an association between EA and both shorter length of stay and lower 30-day readmissions. Further prospective studies are needed to validate these findings.

Key Words: early ambulation ■ heart failure ■ hospitalization ■ length of stay ■ Medicare

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WHAT IS NEW?

- This study investigates the rates of early ambulation and its association with length of stay, discharge disposition, 30-day readmissions and mortality.
- This study identifies whether early ambulation is an inexpensive intervention, which could serve as an additional quality metric to evaluate care of patients hospitalized with acute heart failure.

WHAT ARE THE CLINICAL IMPLICATIONS?

- Heart failure burdens the healthcare system with a huge population or patients incurring multiple readmissions and long lengths of stay.
- Low-cost interventions like early ambulation may help to improve their outcomes.

Patients hospitalized with heart failure (HF) often have multiple comorbidities, older age, and increased frailty contributing to long length of stay (LOS) and high rates of discharge to subacute care.[1,2] Moreover, because of symptomatic dyspnea with exertion, their activity is limited. Mechanically ventilated patients undergoing monitored exercise with a trained physical therapist within 48 hours of ventilation have better outcomes, including higher rates of discharge to home, fewer days in the intensive care unit, and less hospital-acquired comorbidities, such as ventilator-associated pneumonia and intensive care unit delirium.[3–5] As a result of these positive data in the mechanically ventilated patient population and similar data in the stroke population,[6] hospitals participating in the Get With The Guidelines-HF (GWTG-HF) quality program are now also encouraged to implement a program of early ambulation (EA) for HF patients.

Exercise has been associated with improved quality of life and reduced readmissions in HF outpatients, but little is known about the effects of EA for inpatients hospitalized with HF.[7,8] However, with the data from mechanically ventilated and stroke populations, we hypothesized that a benefit likewise exists for hospitalized HF patients. To our knowledge, this hypothesis has never been tested. In fact, a systematic review published in 2013 concluded that no published studies exist that examine the safety and efficacy of EA[9] among hospitalized HF patients.

We hypothesized that there is a wide variability in the implementation of EA and that multiple patient, system, and demographic factors influenced compliance. In addition, we hypothesized that EA, assessed by documentation of ambulation by day 2, would be associated with reduced LOS and a higher likelihood of discharge to independent living versus a subacute care facility. As an exploratory hypothesis, we also predicted that EA would be associated with reduction in clinical end points of postdischarge 30-day readmissions and 30-day mortality among fee-for-service Centers for Medicare and Medicaid Services (CMS) beneficiaries for whom we had linked Part A data and, hence, outcomes.

METHODS

Data Sources

We used data from the GWTG-HF registry between January 1, 2009, and December 30, 2015. The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure. The entry criteria for the registry, HF ascertainment methods, and registry protocols have been described previously.[10,11] Among a subset of patients using a previously described methodology, we linked Medicare Part A files among enrolled fee-for-service Medicare beneficiaries, from January 1, 2009, through December 30, 2013, to examine short-term clinical outcomes such as 30-day readmission rates and 30-day mortality. CMS linkage is strictly for outcomes such as readmission or death.[12] The study was approved by the Duke Clinical Research Institute (DCRI) institutional review committee.

Study Population

After exclusions, the study population consisted of 285 653 patients at 369 sites participating in the GWTG-HF registry. Exclusions included patients who expired, left against medical advice, or in whom the discharge destination was unknown (19 040 patients). In addition, patients who underwent coronary artery bypass surgery, cardiac valve surgery, left ventricular assist device implantation, or heart transplant were also excluded (2130 patients). Those in whom the EA parameter was left blank were also excluded (43 882 patients; Figure 1) If a patient had multiple admissions, we used the first hospitalization as the index admission. We also used indirect identifiers to link data from the GWTG-HF registry with CMS data, as previously described.[12] For the subgroup analysis linking CMS data, the study population consisted of 54 190 patients in 248 hospitals. Exclusions included patients admitted after 2013 (1412), patients not enrolled in fee-for-service Medicare at admission (2417 patients), and a second or later episode for 1 patient (16 600 patients).

Early Ambulation

GWTG-HF defines EA as a patient ambulating without assistance. The use of a cane or other device still meets this definition. Even if actual ambulation is not documented in the medical record, privileges to walk to and from the bathroom and evidence of the patient getting out of the bed unassisted are considered to meet the definition.

This variable was entered into the web-based registry and was treated as a binary variable for the analyses. We examined the association of EA with our outcomes of interest at the hospital level. At the hospital level, we determined hospital quartiles of EA by individual hospital. The

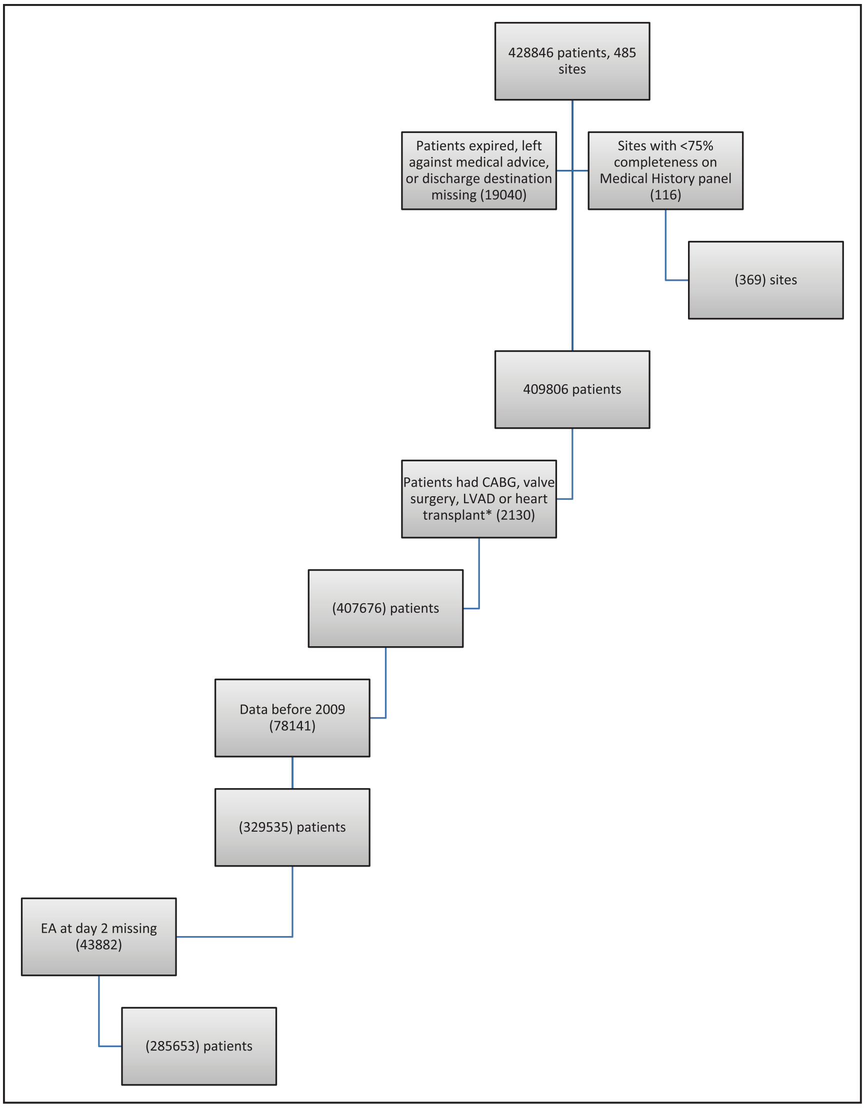

Figure 1. Study population. CABG indicates coronary artery bypass surgery; EA, early ambulation; and LVAD, left ventricular assist device.

overall median EA rate at the hospital level was considered to be the 50%, and quartiles were divided above and below this level.

Patient and Hospital Characteristics

From the registry data, we obtained patient demographics, medical history panel, laboratory results at admission, discharge status, hospital characteristics, adherence to quality measures, and other outcomes. Achievement measures are defined by GWTG-HF as those processes or aspect of care with such strong supporting evidence that failure to adhere to them would result in suboptimal care. Quality measures are those processes or aspects of care that are strongly supported by science, but may not be as universally indicated as achievement measures. At this point, EA falls into the quality measures category.[13] Patient history and demographic variables had low (<5%) rates of missing values except for insurance (17%). However, clinical variables were less reliably recorded. Vital signs at admission had a range of missing rates from 18% (heart rate) to 49% (respiratory rate). Laboratory values including brain natriuretic peptide and troponin levels were also frequently missing (67% and 51%, respectively). In sensitivity analyses, we found that including these data did not change the primary outcomes (data not reported).

Outcomes

We used LOS, defined as day of discharge minus day of admission, and treated it as a Poisson distribution. We also examined long LOS (LOS of >4 days) and discharge home as binary variables. These 3 outcomes served as the primary outcomes. Secondary outcomes included 30-day readmission rate and 30-day mortality using CMS-linked data. Transfers to or from another hospital did not count as readmissions. Emergency department visits that did not result in an admission did not count as a readmission. We calculated the time to death as the number of days between the discharge date and the death date, using the Medicare files.

Statistical Analysis

Descriptive Analytics

Patient and hospital characteristics, achievement, and quality measures were summarized descriptively by EA (yes versus no). Hospital-level site characteristics were summarized descriptively by EA rate (above median versus under median) at hospital level. *P* values based on Pearson χ^2 test or Wilcoxon test are reported.

Multivariable logistic regression modeling was performed to evaluate the association between patient and hospital characteristics and EA. The generalized estimating equation method was applied to provide valid inference after accounting for the within-site correlation.

Primary Analysis

Our primary analysis was a hospital-level analysis based on hospital rates of EA stratified by hospital quartiles. We used multivariable logistic regression models to assess the association between the quartile variable and outcomes. Although the EA rate was calculated at hospital level, the models are at patient level. Covariates in the models included patient demographics, medical history, and hospital characteristics. For the LOS model, because of skewed distribution, Poisson regression with log link was used. The results shown are therefore a risk ratio rather than an odds ratio (OR). Using the CMS-linked data, we assessed the association between the quartile variable and outcomes using Cox proportional hazards regression models.

Patient-Level Analysis

Multivariable logistic regression modeling was performed to evaluate the association between EA and the 2 outcomes (LOS >4 days and discharge home). Both unadjusted and adjusted OR and 95% confidence intervals (CIs) are reported. The generalized estimating equation method was used. Because of skewed distribution, Poisson regression with log link was used to model the association between EA and the LOS. The results are therefore presented as a risk ratio.

Subgroup Analyses of Patient-Level Results

To examine the relationship between EA and 30-day outcomes (postdischarge readmission and mortality), we used the CMS-linked data in Cox proportional hazards regression models for time-to-first event. Both unadjusted and adjusted analyses were performed using the same covariates used in the primary models. The hazard ratio for EA and corresponding 95% CIs and *P* value are reported.

Because clinical and laboratory data were often missing in our data set, we undertook a subgroup analysis using these measurements as covariates in each of our previously described models. The specific covariates used were systolic blood pressure, heart rate, brain natriuretic peptide, sodium, creatinine, and left ventricular ejection fraction. Multivariable logistic regression models were performed for discharge home and LOS outcomes. Because of skewed distribution, Poisson regression with log link was used to model LOS in days. The result shown is therefore a risk ratio instead of an OR. Cox proportional hazards regression models using the same covariates were performed for 30-day readmission and 30-day mortality outcomes.

RESULTS

Hospital and Patient Characteristics

The final study population consisted of 369 hospitals (Figure 1) serving 285 653 patients. Across all participating hospitals, the median EA rate for the total population was 71.2% (interquartile range [IQR] 55.1%–84.4%) and rate quartile distribution was uniform (Table 1). CMS-linked data showed a slightly lower median EA rate of 63.8% (IQR, 50.0%–78.3%; Table 1).

Hospital characteristics are presented in Table 2. Overall, 45% of hospitals were considered academic. Hospitals in the South made up 36% (132 hospitals) of the population with the West being the least represented (14%). Forty-four (11.9%) hospitals were considered rural. Only 4.3% performed heart transplants.

Patient characteristics across EA rate quartiles are presented in Table 3. The median age in the overall population was 75 years (IQR, 63–84), and 48.9% (139 714 patients) were women. Forty-eight percent of patients (139 181 patients) were covered under Medicare or Medicaid with only 3.3% (9395 patients) having no insurance (Table 3). The median systolic blood pressure was 139 mm Hg (IQR, 120–160), and the median brain natriuretic peptide was 799 ng/mL (IQR, 387–1570). Forty-four percent of patients (124 287 patients) had a left ventricular ejection fraction of <40%. For eligible patients, adherence to quality measures varied widely but was consistent with other published reports. Ninety-five percent (78 323 patients) of eligible patients were prescribed an angiotensin converting enzyme inhibitor/angiotensin II receptor blockers (ACE/ARB) at discharge, but only 40.1% (36 347 patients) were prescribed an aldosterone antagonist. Plans for implantable cardioverter-defibrillator (ICD) or cardiac resynchronization therapy implantation at discharge for appropriate patients were made 62.4% and 51.9% of the time, respectively. Patients who ambulated early tended to receive more evidence-based care than those who did not have EA (*P* values <0.01 for all performance measures).

Table 1. Hospital-Level EA Rate Quartiles for Total Population From GWTG-HF Data and the GWTG-HF Data That Were Linked to CMS

	Median EA Rate (IQR)
GWTG-HF data	
Q4 (≥84.4%)	90.8% (87.4%–96.1%)
Q3 (71.2%–84.4%)	79.0% (75.1%–81.6%)
Q2 (55.1%–71.2%)	64.4% (59.9%–67.9%)
Q1 (<55.1%)	40.4% (28.2%–49.6%)
GWTG-HF data linked to CMS	
Q4 (≥78.3%)	86.9% (83.3%–92.9%)
Q3 (63.8%–78.3%)	72.0% (66.7%–75.4%)
Q2 (47.0%–63.8%)	57.1% (52.6%–61.0%)
Q1 (<47.0%)	32.0% (20.4%–39.5%)

EA indicates early ambulation; and GWTG-HF, Get With The Guidelines with Heart Failure.

Table 2. Hospital Characteristics Stratified by Median EA Rates

Variable	Total (369)	High EA* (N=185)	Low EA* (N=184)	*P* Value	Missing (%)
No. of beds, median (IQR)	282 (159 139)	288 (160 483)	279 (158 417)	0.70	11.7
Heart transplant capability, N (%)	16 (4.3)	8 (4.3)	8 (4.3)	0.65	37.9
Academic hospital, N (%)	166 (45.0)	78 (42.2)	88 (47.8)	0.83	11.1
Region, N (%)					
West	53 (14.4)	29 (15.7)	24 (13.0)	0.02	0.5
South	132 (35.8)	57 (30.8)	75 (40.8)		
Midwest	80 (21.7)	51 (27.6)	29 (15.8)		
Northeast	102 (27.6)	46 (24.9)	56 (30.4)		
Rural location, N (%)	44 (11.9)	26 (14.1)	18 (9.7)	0.20	1.1

EA indicates early ambulation.
*High EA defined as greater than the overall median EA rate. Low EA defined as less than the median EA rate.

Primary Hospital-Level Analyses

Hospital characteristics were similar at high and low (above and below the median) EA rate facilities except regionality (Table 2). Hospitals in the South were more likely to have lower EA rates, and hospitals in the Midwest were more likely to have high EA rates (*P*=0.02).

Overall, the median LOS was 4 days (IQR, 3–6), and 96 668 patients (33.8%) had an LOS >4 days. Discharge dispositions varied with the largest majority of patients (75.5%, 215 524 patients) being discharged to home. Nineteen percent 54 365 patients were discharged to another healthcare facility and 3.4% (9725 patients 9725) to hospice either at home or inpatient.

After adjustment for baseline characteristics, predictors of EA included age, male sex, and hospitalization in the Midwest or South when compared with the Northeast (*P*<0.001 for all). Patients with comorbidities such as diabetes mellitus and prior stroke were 14% and 22% less likely to have EA, respectively. Hospital site characteristics such as heart transplant capability, academic status, and rural location were not significantly associated with EA (Table 4).

In the adjusted analyses, we found a significant association for patients in those hospitals in the fourth quartile of EA rates (top 25%) compared with those in the first quartile (bottom 25%) for long LOS (OR, 0.83; CI, 0.73–0.94; *P*=0.004; Table I in the Data Supplement; Figure 2). After linking the CMS data, we found that patients in those hospitals in the highest quartile of EA rates had a lower 30-day readmission rate (hazard ratio, 0.88; CI, 0.82–0.94; Table II in the Data Supplement; Figure 2). Trend testing confirmed a dose-responsiveness to EA for long LOS and 30-day readmission rates, but not for the other outcomes (Table 5; Figure 2). No other significant associations were found.

Sensitivity Analyses

At the patient level, in both the unadjusted and adjusted models, EA was associated with a higher likelihood to be discharged to home (OR, 4.1; CI, 3.9–4.3; and OR, 3.7; CI, 3.5–3.9, respectively). Furthermore, in both models, EA was associated with a lower likelihood to have a long LOS (OR, 0.48; CI, 0.46–0.51; and OR, 0.48; CI, 0.45 to −0.5, respectively). Finally, the LOS for patients with EA decreased 24.3% (risk ratio, 0.757; CI, 0.74 to −0.78) compared with patients without EA in the adjusted analysis (Table 6). Of the 54 190 patients in the study population linked to CMS data, 33 700 (62.2%) ambulated by hospital day 2. EA was associated with a 21% reduction in 30-day readmissions and a 61% reduction in 30-day mortality.

DISCUSSION

To our knowledge, our study is the first to examine EA in detail in the hospitalized HF population. Using GWTG-HF data and CMS data, we assessed the frequency of EA and risk factors for failing to ambulate by day 2 of hospitalization. We also examined the association of EA with outcomes including LOS, discharge disposition, 30-day readmission, and mortality rates. We found that there are predictors of EA including patient age, medical history, and comorbidities as well as hospital type, location, and size. Knowing these predictors can help guide providers to identify high-risk patients who might need more emphasis on physical therapy and nursing encouragement to ambulate while hospitalized. In addition, we found that significant and favorable associations exist between EA and long LOS. In analyses using CMS-linked data, we found that EA was also associated with lower rates of 30-day postdischarge readmissions. Patient-level analyses revealed significant associations with markedly large effect

Table 3. Patient Characteristics Stratified by Early Ambulation Rate Quartiles*

Variable	Level	Total N (285 653)	Overall	N (43 309)	Top 25%	N (85 607)	Bottom 25%	*P* Value
Age*	Median	285 653	75.00	43 309	75.00	85 607	77.00	<0.0001
	25th		63.00		63.00		66.00	
	75th		84.00		84.00		85.00	
Sex	Female	139 714	48.91	20 553	47.46	41 240	50.37	<0.0001
	Male	145 939	51.09	22 756	52.54	44 367	49.63	
Race	White	194 314	68.02	32 436	74.89	56 145	71.51	
	Black or African American	53 466	18.72	6349	14.66	20 085	11.64	
	Hispanic	21 278	7.45	2830	6.53	6014	10.23	
	Missing	3760	1.32	293	0.68	584	3.14	
Insurance	No insurance	9395	3.29	939	2.17	3606	2.23	<0.0001
	Medicare	139 381	48.79	22 780	52.60	42 415	45.19	
	Medicaid	27 849	9.75	4375	10.10	7322	7.67	
	Other	58 605	20.52	7228	16.69	15 926	23.62	
	Missing	50 423	17.65	7987	18.44	16 338	21.30	
Chronic or recurrent atrial fibrillation	Yes	103 678	36.96	16 825	39.09	29 518	39.18	<0.0001
	No	176 868	63.04	26 214	60.91	53 960	60.82	
COPD or asthma	Yes	92 667	33.03	14 177	32.94	27 835	33.03	0.4268
	No	187 879	66.97	28 862	67.06	55 643	66.97	
Diabetes mellitus—insulin treated	Yes	62 626	22.32	9233	21.45	18 698	22.91	<0.0001
	No	217 920	77.68	33 806	78.55	64 780	77.09	
CAD	Yes	140 165	49.96	21 424	49.78	41 449	52.04	<0.0001
	No	140 381	50.04	21 615	50.22	42 029	47.96	
History of HF	Yes	200 886	71.61	30 597	71.09	60 011	71.75	0.2600
	No	79 660	28.39	12 442	28.91	23 467	28.25	
Dialysis	Yes	10 627	3.79	1205	2.80	3671	3.52	0.5501
	No	269 919	96.21	41 834	97.20	79 807	96.48	
Smoking	Yes	46 315	16.21	7199	16.62	14 935	13.16	<0.0001
	No	237 206	83.04	35 996	83.11	70 458	84.70	
	Missing	2132	0.75	114	0.26	214	2.14	
Ejection fraction <40	Yes	124 287	43.51	18 103	41.80	38 742	41.70	<0.0001
	No	155 971	54.60	24 541	56.66	45 195	56.01	
	Missing	5395	1.89	665	1.54	1670	2.29	
Length of stay*	Median	227 709	4.00	34 744	4.00	70 034	4.00	<0.0001
	25th		3.00		3.00		3.00	
	75th		6.00		6.00		6.00	
	Mean		5.14		4.87		5.22	
	Missing (%)		20.28		19.78		22.30	
Length of stay >4 d	LOS >4 d	96 668	33.84	13 589	31.38	29 985	33.80	<0.0001
	4 d	131 041	45.87	21 155	48.85	40 049	43.90	
	Missing	57 944	20.28	8565	19.78	15 573	22.30	
Discharge destination	Other healthcare facility	54 365	19.03	7838	18.10	14 685	21.84	<0.0001
	Acute care facility	5086	1.78	718	1.66	1257	2.15	
	Hospice—healthcare facility	4739	1.66	779	1.80	1345	1.77	
	Hospice—home	5939	2.08	955	2.21	1931	1.79	
	Home	215 524	75.45	33 019	76.24	66 389	72.45	
Discharge home	Yes	215 524	75.45	33 019	76.24	66 389	72.45	<0.0001
	No	70 129	24.55	10 290	23.76	19 218	27.55	

CAD indicates coronary artery disease; COPD, chronic obstructive pulmonary disease; HF, heart failure; and LOS, length of stay.
*Data obtained at the patient level.

Table 4. Factors Associated With Early Ambulation

Variable	χ^2	OR	Lower Limit of 95% CI	Upper Limit of 95% CI	*P* Value
Age (per 10-y increase)	160.37	0.98	0.97	0.98	<0.0001
Race (White vs other)	1.27	0.97	0.93	1.02	0.2601
Sex (female vs male)	80.68	0.84	0.81	0.87	<0.0001
Insurance (Medicare vs no insurance)	0.67	0.95	0.83	1.08	0.4131
Medical history of atrial fibrillation	1.43	0.98	0.95	1.01	0.2319
Medical history of COPD or asthma	6.39	0.94	0.89	0.98	0.0114
Medical history of diabetes mellitus	61.95	0.86	0.83	0.90	<0.0001
Medical history of CAD	12.52	1.06	1.03	1.10	0.0004
Medical history of HF	3.29	0.94	0.88	1.00	0.0696
Medical history of smoking	16.13	1.08	1.04	1.12	<0.0001
Region (Midwest vs Northeast)	10.75	3.65	1.68	7.91	0.0010
Region (South vs Northeast)	11.58	3.77	1.76	8.10	0.0007
Region (West vs Northeast)	7.23	2.89	1.33	6.25	0.0072
Heart transplant performed at site	1.44	1.88	0.67	5.24	0.2297
Hospital type (academic vs nonacademic)	1.99	0.63	0.34	1.19	0.1587
No. of beds (per 100 increase)	3.56	1.00	1.00	1.00	0.0591
Rural vs urban	0.55	0.83	0.50	1.37	0.4580

CI indicates confidence interval; HF, heart failure; and OR, odds ratio.

sizes, suggesting unmeasured confounding, likely because of patient frailty. Taken together, these findings should be viewed as hypothesis generating, but help set the stage for potential prospective evaluation of EA to improve short-term outcomes in patients hospitalized with HF.

Literature using data from mechanically ventilated inpatients suggests that EA improves outcomes. Patients undergoing a relatively inexpensive and low intensity monitored exercise program with a trained physical therapist have higher rates of discharge to home and fewer days in the intensive care unit.[3,5] Although some of these studies were retrospective, and therefore subject to confounding by patient frailty, there was a subsequent small randomized trial that also associated early exercise therapy with improved outcomes including better functional status at discharge and reduced rates of intensive care unit delirium.[4] Furthermore, small randomized trials have shown improved outcomes when stroke patients are mobilized 24 to 48 hours after admission.[14–18] However, it does seem that very early mobilization (within 24 hours) may not be associated with the same improvement in outcomes and could potentially cause harm.[19] The knowledge from these prior studies suggests that careful study in the HF population is warranted before EA is universally implemented beginning with documentation of current practices such as that currently underway in the GWTG-HF registry.

Unfortunately, data describing the effects of EA in HF are inconsistent. The 1 major randomized trial looking at the effects of exercise training on health status in outpatients with chronic HF (HF-ACTION [Heart Failure: A Controlled Trial Investigating Outcomes of Exercise Training]) showed nonsignificant reductions in all-cause mortality or hospitalization.[7,8] Furthermore, the trial did not include patients with HFpEF, a significant proportion of the HF population.[20,21] However, in prespecified secondary analyses that included adjustments for patient severity factors such as cardiopulmonary exercise duration,

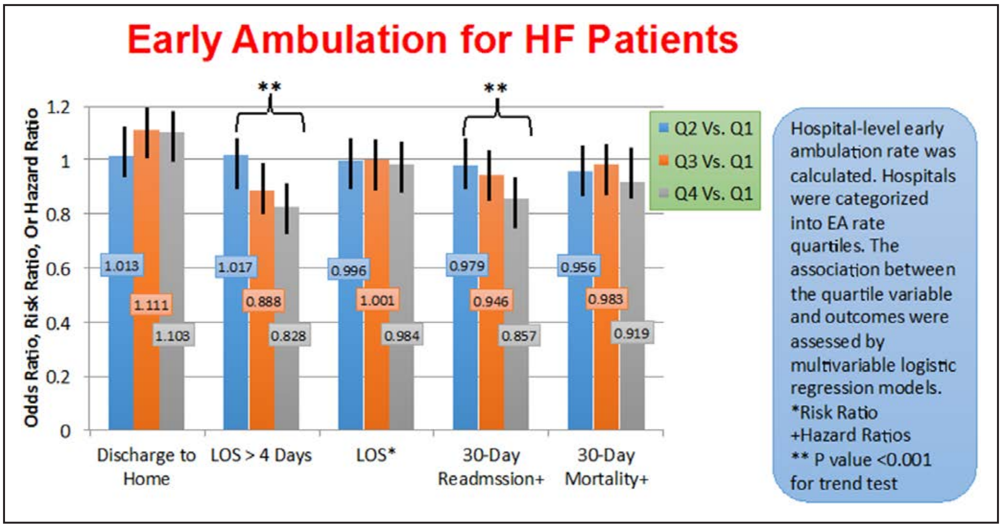

Figure 2. Outcomes of interest by hospital-level quartiles.
EA indicates early ambulation; HF, heart failure; and LOS, length of stay.

Table 5. Trend Test for Primary Outcomes and CMS-Linked Secondary Outcomes Across EA Rate Quartiles

Outcome	OR	Lower 95% CI	Upper 95% CI	*P* Value
Primary outcomes				
Discharge home	1.04	0.99	1.10	0.149
LOS>4 d	0.93	0.90	0.97	0.001
LOS	0.99	0.98	1.01	0.696
CMS-linked secondary outcomes				
30-d readmission	0.96	0.94	0.98	<0.001
30-d mortality	0.98	0.95	1.01	0.220

CI indicates confidence interval; EA, early ambulation; LOS, length of stay; and OR, odds ratio.

exercise was associated with reductions in mortality and hospitalizations as well as improvement in quality of life.

Despite the paucity of published data, the American College of Cardiology/American Heart Association guidelines recommend exercise in outpatients with HF.[22] Our data suggest that close to two thirds (65.5%) of hospitalized HF patients are already participating in EA. This may reflect the overall quality of hospitals participating in the GWTG-HF registry given that 91% of eligible patients met all of the recorded quality measures (ACE/ARB and β-blocker prescription, assessment of LV function, and discharge instructions). Indeed prior data suggest that hospitals participating in GWTG-HF have higher rates of adherence and lower readmission rates, however, no difference in mortality rates.[23]

Furthermore, with over 1 million hospitalizations and estimated indirect and direct costs of estimated to approach $70 billion yearly by 2030, HF places a significant economic burden on payers and the healthcare system in addition to significant morbidity for patients.[24] Readmissions are a large proportion of this cost spurring various and variably effective efforts to reduce them.[25–31] If EA is comparably successful for HF as it is with mechanically ventilated and stroke patients, the benefit to patients, as well as the cost savings, could be substantial.

As with prior studies, we knew that patient frailty would be a significant confounder, and because regression analyses cannot completely account for confounding, we chose to examine hospital-level data to partially remove patient-level variation as a potential confounder. However, residual confounding may remain in a hospital-level analysis depending on hospital and physical therapy resources and nurse:patient ratios. We found that significant associations included lower rates of long LOS and 30-day readmissions between the hospitals with the highest EA rates and those with the lowest. In addition, there seemed to be a dose-responsiveness to EA with larger associations between hospitals in quartiles second and fourth than comparisons between the hospitals in the third and fourth quartiles. For example, the association of EA with 30-day readmissions in the second and fourth quartiles had a *P* value of 0.06, whereas the *P* value comparing the third and fourth quartiles was only 0.5. Trend tests on these data were significant (*P*=0.0002).

Secondary analyses at the patient-level found several other significant associations; however, these are likely confounded by patient frailty. For example, in adjusted models, we did find a significant and favorable association between EA and discharge to home and LOS. Patients with EA were >3.5× as likely to be discharged to home and had a 25% reduction in their LOS.

The results of these secondary analyses are interesting for many reasons. First, we found that even with enormous data sets and a multitude of covariates, regression models cannot always account for all confounders. This should remind us of the limitations of retrospective analyses and perhaps motivate further research to include a randomized, prospective trial to better assess EA in HF inpatients. Second, patient frailty itself may be a difficult confounder to assess with our current clinical registry data. Improvements in registry data collection could include literature-proven, validated instruments to quantify frailty. Finally, in the adjusted model, the only hospital-level variable with significance was region of the country. Whether this reflects variation in regional practices, available resources, or differences in patient population is unknown.

Limitations

As mentioned above, the use of retrospective data is this study's biggest limitation. We have attempted to over-

Table 6. Patient-Level Association of Early Ambulation and Discharge Home as well as Length of Stay

	Unadjusted				Adjusted			
Outcome	OR	Lower 95% CI	Upper 95% CI	*P* value	OR	Lower 95% CI	Upper 95% CI	*P* Value
Discharge home	4.10	3.88	4.34	<0.001	3.66	3.46	3.86	<0.001
LOS>4 d	0.48	0.46	0.51	<0.001	0.48	0.45	0.50	<0.001
Outcome	RR				RR			
LOS	0.76	0.74	0.78	<0.001	0.76	0.74	0.78	<0.01

CI indicates confidence interval; LOS, length of stay; OR, odds ratio; and RR, risk ratio.

come the unmeasured confounding by using a large data set with many measured covariates for the regression analyses. In addition, we used hospital-level, rather than patient-level data, to avoid confounding by patient frailty because we hypothesized that frailty significantly confounds the patient-level analyses. Our analyses suggest that this hypothesis was true. In addition, as it is also retrospective data, we cannot be sure that the hospital-level analyses are not also affected by confounders. There is likely unmeasured confounding based on the population each hospital serves; however, we thought this was the best analysis available and it demonstrates an important association with LOS and 30-day readmissions.

As with other quality improvement data sets, the data capture is limited by provider input so we have a significant amount of missing data. In addition, it is possible that these data do not reflect the total population of hospitals in the United States, but rather a subset that participate in quality improvement programs and therefore have perhaps higher standards of care. We recognize these results are hypothesis generating and need to be validated in a prospective clinical trial.

Conclusions

EA is associated with decreased hospital LOS and post-discharge 30-day readmissions for patients with HF and could be a simple, low-cost intervention to improve care in this patient population. Further prospective cluster-randomized trials would help answer this important question, potentially saving the healthcare system large amounts of money and simultaneously improving outcomes for patients.

ARTICLE INFORMATION

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Disclosures

Dr Kociol receives honorarium for American Heart Association Spotlight Series talks on preventing readmissions (minor); in Transcatheter Cardiovascular Therapeutics (TCT) conference of Travel and Lodging for speaking (minor); and in DCRI of honorarium for being on study steering committee and academic faculty (minor). Dr Fonarow is a member of research in National Institutes of Health and is a consultant of Amgen, Janssen, and Novartis. Dr Hernandez is a member of research of AstraZeneca, Luitpold, Merck, and Novartis; is a consultant of Amgen, AstraZeneca, Bayer, Boston Scientific, and Novartis. Dr DeVore receives research support from the American Heart Association, Amgen, National Heart, Lung, Blood Institute and Novartis and is a consultant with Novartis. The other authors report no conflicts.

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SUPPLEMENTAL MATERIAL

Supplementary Table 1. Hospital EA Rate and Association with Short-Term Outcomes

		Unadjusted				**Adjusted**			
Outcome	**Variable**	**OR**	**Lower 95% CI**	**Upper 95% CI**	**P-value**	**OR**	**Lower 95% CI**	**Upper 95% CI**	**P-value**
Discharge Home	Q1 vs. Q4	1.1	0.96	130	0.17	1.10	0.92	1.32	0.28
	Q2 vs. Q4	1.2	1.02	1.36	0.03	1.11	0.94	1.32	0.22
	Q3 vs. Q4	1.1	0.98	1.30	0.11	1.01	0.86	1.19	0.88
LOS>4 Day	Q1 vs. Q4	0.8	0.66	0.86	<.0001	0.83	0.73	0.94	0.004
	Q2 vs. Q4	0.9	0.78	1.00	0.06	0.89	0.78	1.01	0.06
	Q3 vs. Q4	0.9	0.87	1.11	0.78	1.02	0.90	1.15	0.79
LOS	Q1 vs. Q4	0.9	0.87	0.99	0.03	0.98	0.93	1.04	0.56
	Q2 vs. Q4	0.9	0.94	1.06	0.97	1.00	0.95	1.05	0.98
	Q3 vs. Q4	0.99	0.93	1.04	0.62	0.99	0.94	1.05	0.88

Supplementary Table 2. Hospital EA Rate and Association with 30-Day Outcomes

		Unadjusted				**Adjusted**			
Outcome	**Variable**	**HR**	**Lower 95% CI**	**Upper 95% CI**	**P-value**	**HR**	**Lower 95% CI**	**Upper 95% CI**	**P-value**
30-Day Readmission	Q1 vs. Q4	0.9	0.82	0.91	<.001	0.88	0.82	0.934	<0.001
	Q2 vs. Q4	0.9	0.90	0.99	0.02	0.95	0.89	1.00	0.06
	Q3vs. Q4	0.9	0.89	0.99	0.03	0.98	0.92	1.04	0.50
30-Day Mortality	Q1 vs. Q4	1.0	0.87	1.04	0.25	0.92	0.83	1.02	0.12
	Q2 vs. Q4	1.0	0.89	1.04	0.38	0.98	0.90	1.08	0.70
	Q3 vs. Q4	0.9	0.85	1.01	0.08	0.96	0.87	1.05	0.36