Published in final edited form as:

J Card Fail. 2011 September ; 17(9): 764–770. doi:10.1016/j.cardfail.2011.04.015.

Risk Factors for Onset of Disability Among Older Persons Newly Diagnosed with Heart Failure: The Cardiovascular Health Study

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Abstract

Background—As the heart failure population continues to age, disability is becoming an increasingly important issue. Our objective was to identify risk factors for the onset of disability in activities of daily living among older persons with heart failure.

Methods—The study population included participants with newly diagnosed heart failure from the Cardiovascular Health Study, a longitudinal study of community-living, older persons. Data were collected through annual examinations. Cox regression modeling was used to examine associations between time-dependent predictors and onset of disability.

Results—Of 461 participants newly diagnosed with heart failure (mean age 78.7 [sd 5.89]), 23% subsequently developed disability. The first year after heart failure diagnosis was the period of greatest risk for onset of disability (chi-square P value <0.001). Factors that were independently associated with disability included: impaired gait speed (HR 2.29, 95% CI 1.34–3.90); impaired cognition (HR 1.87, 95% CI 1.14–3.05); and depressive symptoms (HR 1.72, 95% CI 1.04–2.83).

Conclusions—Onset of disability is a common occurrence among older persons newly diagnosed with heart failure. Risk factors for onset of disability in this population are potentially modifiable, and should be routinely assessed in an effort to reduce disability in this growing population.

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Relationship with industry: none

Conflicts of Interest: none

Disclosures

A full list of principal CHS investigators and institutions can be found at <http://www.chs-nhlbi.org/pi.htm>. The manuscript was reviewed and approved by the Cardiovascular Health Study Publications Committee. The funding sources had no role in the design, conduct, or analysis of the study or in the decision to submit the manuscript for publication.

Keywords

Epidemiology; Geriatric conditions; Activities of daily living; Functional status

INTRODUCTION

As the population has aged and survival with cardiovascular disease has increased, the number of older persons with heart failure has expanded considerably over the past 20 years.¹ Currently, 80% of patients with heart failure are 65 years or older, and nearly 25% are 80 years or older.² Prior work has demonstrated that among persons with heart failure older persons are more likely than younger persons to be disabled,³ but relatively little is known about the risk factors for developing disability among older persons with heart failure.⁴⁻⁶ The burden of disability in an aging society is one of the most pressing problems facing our healthcare system today. Onset of disability can lead to loss of independence, the need for hospital and long-term nursing-home care, and premature death.⁷⁻⁹ The additional cost of medical and long-term care for newly disabled older Americans is estimated to be \$26 billion per year.¹⁰ Furthermore, older persons report maintaining functional independence (i.e., avoiding disability) as a critical determinant of quality of life.¹¹

The objective of this study was to identify risk factors, for the onset of disability in activities of daily living (ADLs) among older persons newly diagnosed with heart failure. The ADLs are a widely used measure of disability and assess tasks important in maintaining independence, including bathing, dressing, walking around the home, getting out of bed, eating, and using the toilet. To accomplish our study objective, we used data from a national sample of community-living older adults with heart failure who were followed annually for up to eight years. A rich array of data was available to evaluate risk factors for disability. This data included demographics, body mass index, and assessments of comorbid diseases and geriatric impairments (conditions that occur in older adults and are typically multifactorial in etiology) which were repeatedly updated throughout the follow-up period to reflect changes in clinical status. By identifying the most potent risk factors for onset of disability in this population, our findings can inform efforts to reduce the burden of disability in older persons with heart failure.

METHODS

Study Population

This study is a secondary analysis of data from the Cardiovascular Health Study (CHS). The original objective of CHS was to identify factors associated with the onset of cardiovascular disease in older persons. In 1989, 5201 men and women aged 65 years or older were recruited from communities across the United States, with an additional 687 African Americans recruited in 1992 to enhance minority representation. Potential participants were identified from Medicare eligibility lists. Potentially eligible persons who were wheelchair-bound or were receiving cancer or hospice treatment were excluded. Complete details on the inclusion/exclusion criteria have been previously reported.¹² By the end of the study period, over 95% of the nondecedents participated in follow-up.

Assembly of the Analytic Sample

During the study period, 668 (11.3%) CHS participants were newly diagnosed with heart failure. We excluded 122 participants because they were already disabled at the time of heart failure diagnosis. Another 77 participants were excluded because they died in the same study period that the heart failure was diagnosed, prohibiting any follow-up assessments for

onset of disability. For the same reason, seven participants were excluded because they developed heart failure in last year of study follow-up. One participant was excluded due to missing demographic data. Hence, the analytic sample included 461 participants with newly diagnosed, i.e. incident, heart failure. Compared with the 208 participants with heart failure who were excluded from these analyses, the 461 included were younger (mean age 81 years versus 79 years, respectively), and were more likely to be male (43% versus 53%), and white (11% versus 21%).

Data Collection

Data were collected every 12 months through in-person interviews and examinations. According to the standardized CHS protocol, development of heart failure (i.e., among participants free of heart failure at the beginning of the study) was ascertained through two mechanisms: hospitalization for heart failure, representing 85% of the new heart failure cases included in the analyses, and self-report of a physician diagnosis of heart failure.¹³ Potential cases of heart failure were adjudicated by an expert panel who reviewed all pertinent data, including history, physical examination, chest radiography, and medications. Participants entered the analysis at the time that their heart failure was confirmed, hereafter referred to as “baseline.”

We chose not to include prevalent cases of heart failure (i.e., those who had heart failure at the time of entry into the study) because these participants may have had heart failure for variable lengths of time. Since there is no information on duration of heart failure among prevalent cases, this variable duration of heart failure could introduce bias.

Study Variables

Ejection fraction was classified as depressed ($< 45\%$) or preserved ($\geq 45\%$) based on clinical studies of left ventricular function (echocardiography, nuclear, or catheterization data) that were typically performed at the time of hospitalization, or protocol CHS echocardiograms, which was performed in study year 7.

Potential Risk Factors—With the exception of sex, race, marital status, and highest level of education, all other variables were updated throughout the study period to reflect changes in status. Specifically body mass index and geriatric impairments may worsen or improve. Chronic diseases that were absent at baseline were updated at the time of diagnosis and remained present throughout the study period.

Demographics: Age was considered in 5-year categories. Sex, race (non-white versus white), marital status (currently married versus not currently married), and highest level of education (less than high school versus at least completion of high school) were also included in the analyses.

Body Mass Index: Based on previous work demonstrating associations of body mass index (BMI) with disability,¹⁴ we selected BMI categories to represent low body weight ($< 18 \text{ kg/m}^2$), normal body weight ($18 - 24.9 \text{ kg/m}^2$), overweight ($25 - 29.9 \text{ kg/m}^2$), and obese ($> 30 \text{ kg/m}^2$), based on data obtained from physical examinations.

Chronic Diseases: We selected chronic diseases for inclusion in these analyses based on previous studies (in general populations, i.e. those including participants with and without heart failure) demonstrating an association with functional disability.¹⁵ The diseases, which were assessed according to the standardized CHS protocol,¹⁶ included: peripheral vascular disease, diabetes mellitus, coronary artery disease (CAD), stroke, and osteoarthritis. The CHS criteria for peripheral vascular disease were based on participant report of exertional

leg pain relieved by rest and/or physician diagnosis of peripheral vascular disease. Participants were considered diabetic if they: reported a diagnosis of diabetes mellitus; had fasting serum glucose greater than 126 mg/dl; had a serum glucose of at least 200 mg/dL 2 hours following the oral glucose tolerance test (OGTT); or reported use of diabetic medications. CAD and stroke were ascertained at annual clinic visits and interim telephone interviews based on self reports of hospitalizations and other acute events. Discharge summaries, cardiac enzyme levels, and electrocardiograms were reviewed by the CHS Cardiovascular Events Committee to classify all potential cases of CAD and stroke. Presence of osteoarthritis was based on physician diagnosis. The status of all diseases was updated annually.

Geriatric Impairments: Geriatric impairments are conditions that occur in older adults and that are typically multifactorial in etiology, but not necessarily related to a specific disease.¹⁷ The status of all geriatric impairments was updated annually. Based on previous studies demonstrating associations with disability,¹⁵ 6 geriatric impairments were evaluated, including impairments in: muscle strength, gait speed, cognitive function, vision, hearing, and psychological status. All impairments were classified as present or absent, as follows. Grip strength, a valid indicator of overall muscle strength¹⁸, was measured in the dominant hand using a hand-held dynamometer.¹⁹ Low muscle strength was defined as the lowest quintile for sex and body mass index.²⁰ Gait speed was assessed by recording the time to walk 15 feet at usual pace, and impaired gait speed was defined as the lowest quintile for sex and height.²¹ The actual cut-point used to indicate impaired gait speed ranged from 0.57 meters/second to 0.65 meters/second.

Cognitive function was measured using the Modified Mini-Mental State Exam (3MS)²² and the Digital Symbol Substitution Test.²³ The 3MS is an expanded version of the Folstein Mini-Mental State Exam, a widely used screening test for dementia.²⁴ The Digit Symbol Substitution Test assesses several cognitive processes, including visual search, visuo-motor coordination, and cognitive flexibility. As in previous CHS work,²⁵ cognitive impairment was defined as a score less than 80 on the 3MS or a score less than 19 (which represents 1.5 SD below the mean score for this group) on the Digital Symbol Substitution Test.

Visual impairment was defined as being unable to see sufficiently well to drive, watch TV, or recognize someone across a room with or without glasses. Hearing impairment was defined as being unable to hear well enough to use the phone, listen to the radio, or carry on a conversation, with or without a hearing aid. Depressive symptoms were classified as present based on a score of at least 8 on the (short form) CES-D.²⁶ The CES-D is a self-reported measure of depressive symptoms experienced during the previous week.

Outcome

Disability: We evaluated the onset of disability in ADLs, as assessed annually during in-person interviews. The specific ADL items assessed included: bathing, dressing, walking around the home, getting out of bed or a chair, eating, and using the toilet. Our focus on ADLs as the outcome of interest was informed by their importance in maintaining independent living.²⁷ When questioned about ADLs, participants were asked to rate the degree of difficulty they had with each item as “none”, “some”, “a lot”, or “unable to do.” To enhance clinical relevance and specificity, ADL disability was defined as “a lot of difficulty” or being “unable to do” at least one of the basic ADLs.

Statistical Analysis

We described the baseline (i.e., at the time of heart failure diagnosis) characteristics of the study population by reporting the mean $\pm$ sd or % for continuous and categorical variables,

respectively. We used a Kaplan-Meier time-to-event function to describe onset of disability. We used Cox regression modeling to evaluate the associations between the potential risk factors and time to onset of disability. All risk factors were modeled as time-varying except demographic characteristics. With the exception of age, sex, and race, which were retained in the final models, we selected factors according to a hierarchical screening process to create a parsimonious, multivariable model.²⁸ First, we evaluated the univariable association between each factor and the onset of disability. Only variables with a p-value ≤ 0.30 were considered further. Next, we sequentially evaluated the correlations among the remaining factors with Spearman's correlation coefficient. Those with a correlation coefficient 0.3 could result in collinearity²⁹; thus we retained a single risk factor based on clinical judgment and the strength of association with ADL disability. We then sequentially evaluated the impact of each of the remaining risk factors on the overall model fit through a series of Cox regression models. To assess each factor's contribution to the model fit, we used a chi-square distribution with degrees of freedom equaling the number of parameters for the added factor, based on the difference in the -2 Log Likelihood ($-2LL$) statistic between the models with and without the factor. After fitting a separate model for each factor, we added the factor with the largest difference in $-2LL$ to the overall model. We continued this process iteratively until no factor significantly increased the model fit based on the $-2LL$ criterion. Lastly, the interactions with final risk factors and demographic characteristics were similarly tested. Participants were censored in the event of death without preceding disability (which occurred in 26% of the cohort).

Rates of missing data were lowest at the beginning of the study period (i.e., $< 5\%$), but increased in later years. By the final year of follow-up, the highest rates of missing data were seen for: grip strength (missing in 15.0%), cognition (missing in 14.6%), gait speed (missing in 13.8%), and ejection fraction (missing in 31%). To explore the issue of bias due to missing data, we determined the ignorability of missing data using both Little's³⁰ and Troxel's³¹ tests. Given the data was missing at random³² we applied sequential longitudinal imputation. Missing data were not imputed after death or terminal loss to follow-up. Demographic data were not imputed, nor was ejection fraction (as only assessments performed after heart failure developed were considered in these analyses).

All statistical tests were 2-tailed, and $P < .05$ was considered to indicate statistical significance. All analyses were conducted using SAS software version 9.2 (SAS Institute, Cary, North Carolina).

RESULTS

As shown in Table 1, 42.5% of participants were age 80 years or older when their heart failure was first diagnosed. Most participants were of white race, and over one-third had less than a high school education. Ejection fraction was depressed in 37.8% of participants who had an assessment. As expected in an elderly heart failure cohort, coronary artery disease was the most common comorbid disease, followed by arthritis and diabetes mellitus. Geriatric impairments were observed most commonly in gait speed and muscle strength, although depressive symptoms were also common.

Disability developed in 23% of all participants with incident heart failure during a median follow-up of 3 years. Most participants who became disabled were limited in one (55.3%) or two (24.3%) ADLs. Getting out of bed (55.3%), walking around the house (46.6%) and bathing (43.7%) were the ADL items affected most commonly, followed by dressing (22.3%) and toileting (19.4%).

As shown in Table 2, several characteristics were significantly associated ($P < 0.05$) with the onset of disability in univariable analyses. BMI categories for overweight and obese, peripheral vascular disease, diabetes mellitus, CAD, stroke, and impaired hearing did not meet the univariable P value criterion ($P < 0.30$) and were not considered further. Marital status was highly correlated ($R > 0.3$) with female sex and, hence, was also excluded from the multivariable analyses.

Shown in the Figure is a Kaplan-Meier plot of disability onset relative to the time of heart failure diagnosis. The first year after heart failure diagnosis was the period of greatest risk for onset of disability (P value < 0.001). Within four years after heart failure diagnosis, more than a quarter of the survivors had become disabled, and over 40% of survivors developed disability within eight years.

In the multivariable analyses, as shown in Table 3, the factors that were significantly associated with the onset of disability included impaired gait speed (HR 2.29, 95% CI 1.34–3.90), cognitive impairment (HR 1.87, 95% CI 1.14–3.05), and depressive symptoms (1.72, 95% CI 1.04–2.83). The model explained 35% of the outcome variability.³³ Interactions were tested between demographic characteristics (age, sex, and race) with gait speed, cognition, and depressive symptoms. None were significant.

DISCUSSION

Our study demonstrates that after being diagnosed with heart failure, the onset of disability is a common occurrence in community-living older persons. Disability developed in 23% of all participants with incident heart failure. In comparison, among CHS participants without heart failure, only 13% became disabled during an eight year follow-up period. (Data not shown.) The higher prevalence of disability among older persons with heart failure compared with older persons without heart failure is not surprising, given that the course of heart failure is often marked by recurrent episodes of clinical decompensation with hospitalization, and often by progressive worsening of cardiac function. This burden of disability underscores the importance of identifying risk factors, particularly those that may be modifiable or amenable to intervention. From a comprehensive array of demographic and clinical features, impaired gait speed and cognition, and depressive symptoms emerged as the strongest risk factors for disability among older persons with newly diagnosed heart failure. Because these factors are potentially modifiable, they should be routinely assessed in older persons with newly diagnosed heart failure. As with other geriatric impairments, however, these factors fall outside the traditional disease-oriented model³⁴ of clinical medicine, thus, may be overlooked in the care of older persons with newly diagnosed heart failure, particularly when the impairments are subtle.^{35–37} If recognized, these impairments could be used in risk stratification (i.e., identification of a high risk group for developing disability), and as possible targets for interventions, including physical therapy for impaired gait speed, caregiver services for cognitive impairment, and psychotherapy or pharmacologic therapy (as appropriate, given other co-existing impairments and diseases) for depressive symptoms.

Ejection fraction did not emerge as a significant risk factor for disability, and this is consistent with previous work showing that clinical outcomes, including mortality and readmission rates, as well as in-hospital complication rates, were similar in older persons with depressed and preserved ejection fraction.³⁸ Female sex and non-white race were associated with increased risk for disability, but did not achieve statistical significance. These demographic factors, while non-modifiable, should be explored in future analyses.

These findings expand our current knowledge regarding disability among older persons with heart failure. Previous studies have examined depressive symptoms and cognitive impairment as predictors of disability among older persons with heart failure, and found both to be strongly associated with disability.⁴⁻⁶ However, these studies have been limited by either their cross-sectional design^{4, 6} or short duration of follow-up, i.e. only a few months.⁵ None has focused on persons with newly diagnosed heart failure, which is pertinent since, as demonstrated in the current study, the period immediately following heart failure diagnosis holds the greatest risk for disability onset. Our study has several other unique strengths. We examined an eight year follow-up period, allowing us to characterize the time course of disability. Rather than relying only on information collected at the beginning of the study, several of our potential risk factors were updated frequently throughout the study period to reflect changes in status. Detailed medical record review supplemented self-reported information for several chronic diseases, enhancing the validity of our data. Attrition for reasons other than death was small, further strengthening the validity and generalizability of our results. Geriatric impairments were assessed using well-recognized, contemporary measures. The disability outcome selected (i.e. ADLs) represents everyday tasks that are important for independent community living, and is among the most widely used measures of disability. We used sophisticated multiple imputation methods to address missing data, an important issue in longitudinal studies of older persons. Missing data can bias results, reduce power, and affect generalizability. The generalizability of our results is enhanced by the fact that the CHS data were collected from a representative sample of white and African-American community-living older persons from across the United States.

This study also has several potential limitations, which should be considered when interpreting our results. Data were collected from 1989 through 1999. Heart failure management has certainly changed since this time and it is possible that the risk factors for developing disability have changed. However, it is important to note that despite changes in heart failure treatment over the past two decades (including medications and device-based therapies), certain outcomes have shown little temporal improvement, including mortality rates in patients with preserved ejection fraction, and readmission rates and mortality after a heart failure hospitalization.^{39, 40} In addition, because CHS excluded institutionalized persons, our analytic sample is not representative of all elderly patients with heart failure. Data were not collected on New York Heart Association class, so we were unable to consider this in our analyses. Although our outcome assessment was based on self-report, and nearly one-quarter of participants had cognitive impairment at baseline, previous work has demonstrated the validity and reliability of self-reported disability among participants with cognitive impairment.⁴¹ Finally, to assess potential risk factors for subsequent disability we restricted our analyses to participants free of disability at the time of heart failure diagnosis. It is possible that new heart failure could precipitate immediate disability, and such cases would be omitted from our analyses. Also, because increasing evidence indicates that disability is often a dynamic process, with episodes of recovery followed by reoccurrence,⁴² it is possible that some cases of disability detected after onset of heart failure were not truly “incident” but actually “recurrent.” However, our focus on severe disability makes the possibility of recovery from disability prior to a diagnosis of heart failure less likely.⁴³ Further, the exclusion of institutionalized persons, and those disabled at the time of heart failure diagnosis, is consistent with our focus on examining the onset of disability among independent, community-living older persons.

Although heart failure primarily affects older persons, particularly those with other complex co-morbid conditions, current studies and guidelines have not incorporated routine assessment of geriatric impairments. Underscoring the relative inattention to impairments, even current quality indicators developed specifically for older patients with heart failure

(the Assessing Care of Vulnerable Elders or “ACOVE” measures for heart failure) do not include assessment of geriatric impairments.⁴⁴ Our results, demonstrating the robust associations between geriatric impairments and onset of disability, provide strong justification for developing strategies to routinely screen for these impairments, which may often be “invisible” to clinicians caring for older patients with heart failure, particularly when the impairments are more subtle.^{35–37} Risk factors can be used not only to inform prognosis, but can also serve as potential targets for intervention. The results of this research can inform future studies to improve outcomes among older patients with heart failure by addressing the modifiable impairments that are most strongly associated with disability. Through such interventions, it may be possible to prevent the onset of disability among older persons newly diagnosed with heart failure, thereby improving their quality of life while reducing health care costs and the need for long-term care.

Acknowledgments

Dr. Chaudhry is the recipient of a Beeson/K23 Career Development Award (K23AG030986) from the NIA/NIH. Dr. Gill is the recipient of a Midcareer Investigator Award (K24AG021507) from the NIA/NIH. The study was conducted at the Yale Claude D. Pepper Older Americans Independence Center (P30AG21342). The CHS was supported by contract numbers N01-HC-85079 through N01-HC-85086, N01-HC-35129, N01-HC-15103, N01-HC-55222, N01-HC-75150, N01-HC-45133, N01-HC-80007, grant numbers R01 HL-075366 and U01 HL080295 from the NHLBI, with additional contribution from the NINDS. Additional support was provided through R01 AG-15928, R01 AG-20098, AG-023629 and AG-027058 from the National Institute on Aging, and the University of Pittsburgh Claude D. Pepper Older Americans Independence Center P30-AG-024827.

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Figure 1.
Onset of Disability after Heart Failure Diagnosis
Participants were censored for developing the outcome and at the time of death.

Table 1

Baseline Characteristics, % (N=461)

Age	
Mean (sd)	78.7 (5.9)
65–69 y	3.7
70–74 y	22.7
75–79 y	31.1
≥80 y	42.5
Sex	
Female	47.0
Race	
Non-white	10.6
Marital status	
Unmarried	32.3
Education	
< high school	35.7
BMI	
<18	2.8
18 – 24.9	42.9
25 – 30	37.5
≥ 30	16.8
Depressed Ejection Fraction	37.8
Chronic Diseases	
Peripheral Vascular	11.3
Diabetes Mellitus	25.5
Coronary Artery	64.9
Stroke	14.3
Arthritis	43.5
Geriatric Impairments	
Muscle strength	37.1
Gait speed	42.3
Cognition	24.2
Vision	21.8
Hearing	13.4
Depressive symptoms	33.6

Note that “baseline” denotes time at which heart failure was first noted.

All factors missing < 5%

Table 2

Univariable Analysis for Onset of Disability (N=461)

	HR(95%C.I.)	P Value
Age	1.17(0.94, 1.45)	0.163
Female Sex	1.57(1.05, 2.32)	0.034
Non-white Race	2.29(1.33, 3.95)	0.003
Unmarried	1.44(0.96, 2.16)	0.070
Education < HS	1.80(1.21, 2.68)	0.004
Body Mass Index < 18	2.40(0.89, 6.49)	0.084
25 ≤ Body Mass Index < 30	0.84(0.52, 1.36)	0.467
Body Mass Index ≥ 30	0.98(0.55, 1.76)	0.954
Depressed Ejection Fraction	1.36(1.06, 1.75)	0.017
Chronic Diseases		
Peripheral Vascular	1.30(0.74, 2.27)	0.356
Diabetes Mellitus	1.09(0.69, 1.71)	0.722
Coronary Artery	0.94(0.62, 1.43)	0.765
Stroke	0.95(0.55, 1.64)	0.854
Arthritis	1.70(1.14, 2.52)	0.009
Geriatric Impairments		
Muscle strength	1.82(1.23, 2.70)	0.003
Gait speed	2.88(1.90, 4.37)	<.001
Cognition	2.84(1.91, 4.23)	<.001
Vision	1.33(0.87, 2.03)	0.199
Hearing	1.07(0.64, 1.79)	0.796
Depressive symptoms	2.05(1.38, 3.04)	<.001

Age categorized as shown in Table 1: 65–69 years, 70–74 years, 75–79 years, and 80+ years

Table 3

Multivariable Model for Onset of Disability (N=461)

	HR (95% CI)	P Value
Age	0.99 (0.77–1.27)	0.925
Female Sex	1.47 (0.96–2.24)	0.073
Non-white Race	1.70 (0.92–3.15)	0.093
Gait speed	2.29 (1.34–3.90)	0.003
Cognition	1.87 (1.14–3.05)	0.013
Depressive symptoms	1.72 (1.04–2.83)	0.035

Age categorized as shown in Table 1: 65–69 years, 70–74 years, 75–79 years, and 80+ years