11-2002

Cognitive Impairment in Heart Failure: Issues of Measurement and Etiology

Barbara Riegel
University of Pennsylvania, briegel@nursing.upenn.edu

Jill A. Bennett

Andra Davis

Beverly Carlson

John Montague

See next page for additional authors

Cognitive Impairment in Heart Failure: Issues of Measurement and Etiology

Abstract

Background: Clinicians need easy methods of screening for cognitive impairment in patients with heart failure. If correlates of cognitive impairment could be identified, more patients with early cognitive impairment could be treated before the problem interfered with adherence to treatment.

Objectives: To describe cognitive impairment in patients with heart failure, to explore the usefulness of 4 measures of cognitive impairment, and to assess correlates of cognitive impairment.

Methods: A descriptive, correlational design was used. Four screening measures of cognition were assessed in 42 patients with heart failure: Commands subtest and Complex Ideational Material subtest of the Boston Diagnostic Aphasia Examination, Mini-Mental State Examination, and Draw-a-Clock Test. Cognitive impairment was defined as performance less than the standardized (T-score) cutoff point on at least 1 of the 4 measures. Possible correlates of cognitive impairment included age, education, hypotension, fluid overload (serum osmolality

Results: Cognitive impairment was detected in 12 (28.6%) of 42 participants. The 4 screening tests varied in effectiveness, but the Draw-a-Clock Test indicated impairment in 50% of the 12 impaired patients. A summed standardized score for the 4 measures was not significantly associated with age, education, hypotension, fluid overload, or dehydration in this sample.

Conclusions: Cognitive impairment is relatively common in patients with heart failure. The Draw-a-Clock Test was most useful in detecting cognitive impairment, although it cannot be used to detect problems with verbal learning or delayed recall and should not be used as the sole screening method for patients with heart failure. Correlates of cognitive impairment require further study.

Disciplines

Cardiology | Cardiovascular Diseases | Circulatory and Respiratory Physiology | Health and Medical Administration | Medical Humanities | Medicine and Health Sciences | Neurology | Neurosciences | Nursing

Author(s)

Barbara Riegel, Jill A. Bennett, Andra Davis, Beverly Carlson, John Montague, Howard Robin, and Dale Glaser

Cognitive Impairment in Heart Failure: Issues of Measurement and Etiology

By Barbara Riegel, RN, DNSc, CS, Jill A. Bennett, RN, PhD, Andra Davis, RN, MS, Beverly Carlson, RN, MS, CNS, CCRN, John Montague, PhD, Howard Robin, MD, and Dale Glaser, PhD. From the School of Nursing, University of Pennsylvania (BR), Sharp HealthCare, San Diego, Calif (BR, AD, BC), School of Nursing, University of California, San Francisco (JAB), San Diego, Calif (JM), Sharp Memorial Hospital, San Diego, Calif (HR), and Pacific Science and Engineering, San Diego, Calif.

• Background *Clinicians need easy methods of screening for cognitive impairment in patients with heart failure. If correlates of cognitive impairment could be identified, more patients with early cognitive impairment could be treated before the problem interfered with adherence to treatment.*

• Objectives *To describe cognitive impairment in patients with heart failure, to explore the usefulness of 4 measures of cognitive impairment, and to assess correlates of cognitive impairment.*

• Methods *A descriptive, correlational design was used. Four screening measures of cognition were assessed in 42 patients with heart failure: Commands subtest and Complex Ideational Material subtest of the Boston Diagnostic Aphasia Examination, Mini-Mental State Examination, and Draw-a-Clock Test. Cognitive impairment was defined as performance less than the standardized (T-score) cutoff point on at least 1 of the 4 measures. Possible correlates of cognitive impairment included age, education, hypotension, fluid overload (serum osmolality <269 mOsm/kg), and dehydration (serum osmolality ≥ 295 mOsm/kg).*

• Results *Cognitive impairment was detected in 12 (28.6%) of 42 participants. The 4 screening tests varied in effectiveness, but the Draw-a-Clock Test indicated impairment in 50% of the 12 impaired patients. A summed standardized score for the 4 measures was not significantly associated with age, education, hypotension, fluid overload, or dehydration in this sample.*

• Conclusions *Cognitive impairment is relatively common in patients with heart failure. The Draw-a-Clock Test was most useful in detecting cognitive impairment, although it cannot be used to detect problems with verbal learning or delayed recall and should not be used as the sole screening method for patients with heart failure. Correlates of cognitive impairment require further study. (American Journal of Critical Care. 2002;11:520-528)*

CE Online

To receive CE credit for this article, visit the American Association of Critical-Care Nurses' (AACN) Web site at http://www.aacn.org, click on "Education" and select "Continuing Education," or call AACN's Fax on Demand at (800) 222-6329 and request item No. 1159.

The prevalence of heart failure has increased more than 150% in the past 20 years.[1,2] Currently, about 4.8 million older adults have heart failure,[3,4] and this number will increase as the population 65 years and older doubles in size during the next 30 years.[5] It is important to understand the

To purchase reprints, contact The InnoVision Group, 101 Columbia, Aliso Viejo, CA 92656. Phone, (800) 809-2273 or (949) 362-2050 (ext 532); fax, (949) 362-2049; e-mail, reprints@aacn.org.

extent to which the signs and symptoms of heart failure can be measured, prevented, or controlled so that patients with heart failure can continue to live independent lives. Cognitive impairment associated with heart failure has been observed clinically, although the correlates of cognitive impairment in patients with heart failure have not been fully investigated. The purpose of this study was to describe cognitive impairment in a sample of patients with heart failure. Four simple measures of cognitive function were assessed as potential screening methods. Possible correlates of cognitive impairment that were assessed were age, education, hypotension, fluid overload, and dehydration.

In the general population, advancing age is associated with cognitive impairment because of the increasing prevalence of medical conditions such as Alzheimer disease, Parkinson disease, and stroke. Approximately 5% to 8% of persons 65 years or older and one third of persons 85 years and older are demented.[6,7] Cognitive impairment can also be caused by factors other than age. Medications,[8-10] nutritional deficiencies,[8] depression,[11] infection,[12] and fluid shifts have all been implicated as causes in the general population.[8,13-16] In particular, dehydration has been associated with cognitive impairment in elderly patients, perhaps because it is an indicator of infection.[17,18] The association between dehydration and cognitive impairment in patients with heart failure has not been studied before.

Cognitive impairment may be more common in patients with heart failure than in the general population.[19-21] Other investigators have reported that 23%[19] to 53%[20] of patients with heart failure have evidence suggestive of cognitive impairment. Cacciatore et al[19] found that the risk of cognitive impairment in patients with heart failure was 1.96 times the risk in the general population 65 years or older. Patients with heart failure experience problems with memory, attention, speed and flexibility of mentation, reaction times, and concentration.[22-28] In studies of patients with heart failure who have measurable cognitive impairment, fluid overload is typically speculated to be the cause.[14,15,19,20,22,29-31] Age[22] and education[22,32] also have been associated with cognitive impairment. Low-output states such as systemic hypotension[21] and low ejection fraction[23] also have been implicated as causes of cognitive impairment in patients with heart failure. However, the research on cognitive impairment in patients with heart failure is inconclusive. We remain unsure about the prevalence of cognitive impairment in the general population of patients with heart failure, how to screen for the problem, and the most likely causes.

Methods

Sample and Procedure

The sample was drawn from an accessible population of 274 patients with heart failure who had participated in an earlier study.[33,34] Patients from those studies had been previously hospitalized, and heart failure had been diagnosed by the attending physician. For each patient, the diagnosis of heart failure had been confirmed by a thorough review of the medical record. Patients were excluded from the earlier study if they did not live independently or if they had a major psychiatric illness, severe renal failure, or a terminal disease such as cancer or AIDS. Patients who were noted clinically to be cognitively impaired at the time of enrollment in any of the prior studies (1-3 years earlier) were excluded from that study, but no prescreening for cognitive impairment was done in this study. The only exclusion criterion was inability to speak English, which was necessary because of the nature of the cognitive testing to be performed.

After approval by the institutional review board, participants from the earlier study were contacted by telephone and invited to participate in the current study. Contact could not be made with 75 of the former participants. Of the 199 contacted, 49 were ineligible for the current study because they did not speak English (n = 23), had moved (n = 19), or had become too ill to participate (n = 7). Fifty-four had died. From the eligible group of 96, 53 (55%) declined to participate in the study. The primary reasons for refusal were lack of interest (n = 19) feeling too ill (n = 11), and being too busy (n = 9). One patient agreed to participate, but did not keep the appointment. The sample size was inadequate for hypothesis testing with confidence but was adequate for the exploratory purpose of this investigation.

Individual appointments for data collection were arranged with each of the 42 patients who agreed to participate in the study. Data collection sessions were conducted between June 16, 2000, and August 25, 2000, and most sessions (86%) were held in the participants' homes. One nurse research associate collected all data for this study by meeting individually with participants in sessions that lasted from 40 minutes to 2 hours. In each session, the nurse described the study in detail and obtained informed consent before beginning data collection. After the consent form was signed, the nurse recorded verbal answers to questions on the demographic survey, questions about other medical conditions, and questions about functional status. Next, she recorded verbal answers or scores for 4 cognitive measures.

When the cognitive measures were completed, the nurse obtained a blood sample and recorded medications by examining drug containers provided by the participants. Finally, the nurse measured the participant's blood pressure. The nurse research associate was trained by a certified laboratory technician to collect blood samples, by a physiologist to handle blood samples, and by a clinical psychologist to assess cognitive function.

Demographic data were gathered from participants by using an investigator-designed survey. Blood pressure was measured by using standard protocols while the patient was sitting. Comorbidity was measured by the count and the type of medical conditions reported by the participant and categorized as low, moderate, or severe by using the weighted index developed by Charlson et al[35] and modified by Katz et al[36] for interviews. Data on activity limitations related to signs and symptoms were obtained by interview and were used to classify patients' functional status according to the New York Heart Association classification system.

Measures of Cognitive Impairment

Cognition refers to those mental activities associated with thinking, learning, and memory. Impaired cognition is suspected when persons have evidence of changes in short-term memory, poor judgment, inability to handle complex tasks, inability to take part in usual activities, and personality change.[37] McDowell and Newell[38] note that cognitive function is often described operationally as success on cognitive tests. In our study, cognitive impairment was operationalized as performance less than the impairment cutoff point on at least 1 of 4 screening measures of cognition. A clinical psychologist experienced with the assessment of cognitive function in elderly persons chose the battery of cognitive measures. In order of administration, these measures were as follows: the Commands subtest of the Boston Diagnostic Aphasia Examination (BDAE),[39] the Mini-Mental State Examination (MMSE),[40] the Draw-a-Clock Test,[39] and the Complex Ideational Material subtest of the BDAE.[39]

The measures chosen are generally considered low-sensitivity screening tests for detection of overt cognitive impairment. These measures were chosen because they can be used to detect problems in 1 or more of the categories in which patients with heart failure experience problems (eg, memory, attention, speed and flexibility of mentation, reaction times, and concentration). Each test is simple to administer and could be used by general staff in a busy clinical setting to screen for cognitive impairment significant enough to interfere with treatment. The MMSE is most commonly used in investigations of impaired cognition in patients with heart failure.[19,20,23,41] In this study, the MMSE and 3 other measures were used to determine which test was the most effective for detecting impairment in a sample of patients without obvious cognitive difficulties.

Commands Subtest. In the Commands subtest, the patient is asked to perform increasingly complex tasks ranging from 1-step (eg, make a fist) to 5-step commands. The test relies on a patient's aural attention span, auditory comprehension, planning and execution, and motor skills. Each patient's score is the step-count of the most complex command correctly performed, and test scores range from 1 to 5. The internal consistency reliability of the Commands subtest is 0.91, and the validity in a normal population has been indicated by a 0.73 correlation with the identified factor in a discriminant analysis.[27] Cognitive impairment was defined as a score of less than 3 on the Commands subtest, as recommended by the authors of the test.[39]

Mini-Mental State Examination. The MMSE is a widely used cognitive screening test. The 30-point test is used to assess a range of abilities, including orientation, attention and concentration, sequencing, visual-spatial skills, verbal learning and immediate memory, oral reading and comprehension, and verbal repetition.[40] The reliability of the MMSE has been consistently high in other studies (Cronbach $\alpha = .96$, test-retest $\geq .89$) and criterion and discriminant validity of the MMSE have been established.[38] Although education may affect MMSE scores,[38] the majority of participants in this study had a high school education or more, an education level for which the MMSE is considered accurate. The standard MMSE cutoff point of less than 24 was used to define cognitive impairment so that the results could be compared with results of other studies.[19,20,23,41]

Draw-a-Clock Test. For the clock-drawing test used in this study, patients were asked to draw the face of a clock, put in all the numbers, and "set the hands for 10 after 11." The research associate assessed drawn clocks for shape, completeness and correctness of numbers (1 point), and appropriate placement of the 2 hands (1 point). This task requires attention and concentration, numerical sequencing, visual-spatial analysis and execution, and abstract conceptualization and planning. Patients were suspected of being cognitively impaired if they performed grossly below expectations in spatial layout, numerical sequencing, or orientation of the detailing of the clock hands.

Scores on this test ranged from 0 to 2, according to the protocol of the authors.[39] A score of 2 represented an appropriately drawn clock, and cognitive impairment was defined as a score less than 2, as recommended by the authors.[39] There are a variety of clock-drawing tests, which show a range of reliability coefficients.[38] Validity has been indicated by correlations between 0.51 and 0.75 with other memory and cognition tests.[38]

Complex Ideational Material Subtest. The Complex Ideational Material subtest is a measure of executive brain functioning.[39] Patients hear a statement or a brief story and answer questions about what they have heard. The test has 8 statements and 4 stories, each with 4 questions (eg, will a cork sink in water?). The stories increase in length and grammatical difficulty. This test relies on attention and concentration, auditory comprehension, short-term memory, and abstract reasoning. The internal consistency reliability of this subtest is 0.89,[27] and the validity has been determined by a 0.54 correlation with the identified factor in a discriminant analysis.[27] Scores on the subtest range from 0 to 12. Cognitive impairment was defined as a score less than 10, as recommended by the authors.[39]

Measures of Hydration

Hydration status was assessed by measuring serum osmolality in an accredited hospital laboratory. Serum osmolality is derived from the calculation of measured serum concentrations of the major solutes sodium, glucose, and urea.[42] In the body, water moves freely between the intracellular and extracellular compartments, making serum osmolality a convenient and accurate measure of intracellular ionic composition.[43] To obtain a blood sample for analysis, the nurse research associate pricked the participant's finger with a sterile lancet (Unistik2, Owen Mumford, Atlanta, Ga) and withdrew blood into a serum tube (Microtainer brand, Becton Dickinson, Franklin Lakes, NJ). The blood was allowed to clot and then was centrifuged in a portable Mobilespin centrifuge (Vulcan Tech, Grandview, Mo) to separate the serum. After centrifuging for 10 minutes at 3000 rpm, the serum was transferred to a clear plastic micro test tube and transported on ice to a freezer maintained at less than 0°C (32 F). The test tubes were stored for up to 8 days (median, 7 days) and then transported by the nurse to the laboratory for analysis.

In this study, normal hydration was defined as serum osmolality between 269 and 294 mOsm/kg. Fluid overload was defined as serum osmolality less than 269 mOsm/kg. Dehydration was defined as serum osmolality of 295 mOsm/kg or higher. These definitions are consistent with those used in other studies.[44,45]

Analysis

The 4 measures of cognitive impairment had limited metrics, so normal distribution was not expected, and the raw scores on all 4 measures were negatively skewed. Further, the raw scores were difficult to compare because of the differences in scale measurements. Therefore, raw scores on the screening tools and published cutoff points were used for initial screening. Then, standardized T-scores (10z + 50) were used to confirm the assessment and to test for correlates of association. T-scores are not usually used for ordinal level data such as data produced by use of the Draw-a-Clock Test, but when the T-scores and raw scores of the Draw-a-Clock Test were compared, the same patients were identified as impaired. Therefore, these data were converted to T-scores to allow them to be aggregated with the other measures. Patients with a T-score of 30 to 35 were considered mildly impaired. Those with a T-score less than 30 or 2 standard deviations below the mean of 50 were considered moderately to severely impaired.

Correlates of cognitive impairment were evaluated by using Pearson product moment correlation coefficients (age, blood pressure, serum osmolality) or the Spearman rho (education). T-scores on the 4 measures of cognition were added together and assessed in relation to the proposed correlates. Age was evaluated by using raw ages (1-tailed test), hypotension was evaluated by using systolic blood pressure (1-tailed test), and hydration status was evaluated by using serum osmolality (2-tailed test to detect fluid overload and dehydration). Education was analyzed after the data were recoded as either less than a high school education or a high school education or greater (1-tailed test). Descriptive statistics were used to characterize the sample. Characteristics of patients who scored less than the impairment cutoff point were compared with characteristics of those who scored greater than the cutoff point by using unpaired t tests and χ^2 tests. All analyses were done by using SPSS version 9.0 (SPSS, Inc, Chicago, Ill).

Results

Table 1 shows the characteristics of the final sample of 42 participants, who were predominately white older adults; most were classified in New York Heart Association functional class II or III. The sample was evenly split by sex. The time since the last hospitalization for heart failure ranged from 1 week to 6 years,

Table 1 Description of the sample of community-dwelling persons with heart failure (N = 42)

Variable	No. of persons	%
Men	21	50.0
Married	14	33.3
Live alone	19	45.2
Education		
Grade school or less	8	19.1
High school only	20	47.6
Business school or associate degree	9	21.4
College degree	5	11.9
White	35	83.3
Work situation		
Homemaker	8	19.0
Working full-time	1	2.4
Retired	33	78.6
New York Heart Association functional class		
I	4	9.5
II	13	31.0
III	20	47.6
IV	5	11.9
Comorbidity category		
Low	17	40.5
Moderate	16	38.1
Severe	9	21.4

Mean age of participants was 74.69 years, with an SD of 12.21 years and a range of 45 to 91 years.

but 65% of the participants had been admitted to the hospital in the prior year for reasons other than heart failure. None of the participants was acutely ill with any medical condition at the time of the interview. The mean number of medical conditions was 3.2, with a range of 1 to 7. The weighted comorbidity scores indicated that 79% of the sample had low or moderate comorbidity.

Mean blood pressure of the participants was 124/60 mm Hg, but systolic blood pressure ranged from 78 mm Hg (1 patient) to 178 to 180 mm Hg (3 patients). Diastolic blood pressure ranged from 38 to 80 mm Hg. Participants took an average of 8 medications daily (range, 2-16), and all but 1 participant routinely took a diuretic, which was usually furosemide.

Data on serum osmolality were available for 34 of the 42 participants. Of the other 8 patients, 2 had serum samples that were analyzed in a different laboratory during pilot testing and were discarded for the final analysis. One patient refused the finger stick, and 1 test was deferred because the participant had a hereditary bleeding condition. Four of the blood samples were inadequate for serum osmolality analysis because they were taken from diabetic patients whose fingers were scarred from multiple finger sticks. In the 34 usable samples, serum osmolality ranged from 237 to 316 (mean, 291 mOsm/kg; SD, 15.5 mOsm/kg). Two participants (6%) were in a state of fluid overload (<269 mOsm/kg), 16 (47%) had normal serum osmolality (269-295 mOsm/kg), and 16 (47%) were dehydrated (≥295 mOsm/kg).

Five participants reported a prior cerebrovascular accident. One of the 5 scored less than the raw score cutoff point on the Complex Ideational Material subtest, but none of the 5 participants was considered cognitively impaired when T-scores were used. Data were analyzed with and without the data from these participants, but the results did not change, so these participants were included in the data analysis. There was 1 outlier in the serum osmolality data (mean, 237 mOsm/kg; $z = -3.51$). Analyses were conducted with and without the outlier, and interpretation did not differ substantively, so analyses reported here included the outlier.

Distributions of raw scores on the 4 cognitive tests are shown in Table 2. Three patients (1 with a prior cerebrovascular accident) were suspected of having cognitive impairment when raw scores were used, but the T-scores did not indicate any impairment, and these 3 patients were classified as not impaired. Conversely, 2 patients were within normal limits when raw scores were assessed but were considered impaired when the T-scores were analyzed. These 2 patients were classified as impaired.

As expected in this sample of patients with heart failure who were living independently in the community, raw scores on all the measures were generally high. Scores on the Complex Ideational Material subtest were significantly correlated with both the MMSE ($r = 0.42$, $P < .01$) and the Commands subtest ($r = 0.56$, $P < .01$), but no other significant associations between test scores were found, suggesting that these cognitive measures were not redundant and may have measured different aspects of cognition.

When raw scores were used, 13 patients (31%) scored less than the cutoff point on 1 or more tests. No one scored less than the cutoff point on the Commands subtest, 1 patient scored less than the cutoff point on the MMSE, 6 scored less than the cutoff point on the Draw-a-Clock Test, and 10 scored less than the cutoff point on the Complex Ideational Materials subtest.

When T-scores were used, 12 patients (28.6%) scored at the impairment level on 1 or more tests. Six were mildly impaired (T-score, 30-35), and 6 were moderately severely impaired (T-score, <30). Four patients scored less than 35 on the Commands subtest,

Table 2 Distribution of raw scores on 4 cognitive tests in a sample of community-dwelling persons with heart failure (N=42)

Commands Subtest of the Boston Diagnostic Aphasia Exam (cutoff point for cognitive impairment, <3)

	Score				
	1	2	3	4	5
No. of persons	0	0	0	4	38
%	0	0	0	9.5	90.5

Mini-Mental State Examination (cutoff point for cognitive impairment, <24)

	Score									
	0-21	22	23	24	25	26	27	28	29	30
No. of persons	0	1	0	0	0	2	8	6	14	11
%	0	2.4	0	0	0	4.8	19.0	14.3	33.3	26.2

Draw-a-Clock Test (cutoff point for cognitive impairment, <2)

	Score		
	0	1	2
No. of persons	1	5	36
%	2.4	11.9	85.7

Complex Ideational Material subtest of the Boston Diagnostic Aphasia Exam (cutoff point for cognitive impairment, <10)

	Score						
	0-6	7	8	9	10	11	12
No. of persons	0	2	3	5	6	13	13
%	0	4.8	7.1	11.9	14.3	31.0	31.0

3 on the MMSE, 6 on the Draw-a-Clock Test, and 4 on the Complex Ideational Material subtest. Four of the 12 patients with a standardized test score less than 35 scored in the moderately severe range (T-score, <30) on at least 1 test; 2 of the 6 did so on 2 of the 4 screening tests.

Table 3 shows the cognition test scores and selected characteristics of the 12 patients who had standardized T-scores less than 35. Serum osmolality was available for only 9 of the 12 patients. As shown in the table, 4 had normal serum osmolality and 5 were dehydrated. No patients who were cognitively impaired on the tests according to the T-score were in a state of fluid overload. Table 4 compares the 12 patients who scored less than the T-score cutoff point with the 30 patients who scored greater than the T-score cutoff point. The 2 groups were not different in any of the measured characteristics.

None of the 5 proposed correlates of cognitive impairment was associated with cognitive impairment in this sample. Neither age (r=-0.08, P=.32) nor education (r=0.18, P=.13) nor hypotension (r=-0.18, P=.12) nor serum osmolality (r=-0.006, P=.97) was related to the summed T-scores of the measures of cognitive impairment.

Discussion

Cognitive impairment is gaining recognition as a sequela of heart failure. In this study of 42 patients with heart failure, 28.6% had evidence of impairment on standardized T-scores of cognitive screening tests. This rate is similar to that reported by Cacciatore et al,[19] who found that 23% of a sample of 1339 community-dwelling patients with heart failure in Italy were cognitive impaired, defined as an MMSE score less than 24. The rate is similar also to the 26% found by Zuccala et al[21] in a study of 13 635 patients (1583 with heart failure) admitted to an Italian hospital between 1995 and 1997 who were classified as cognitively impaired after scoring less than 7 on the Hodkinson Mental Test. These results differ from those of an earlier study[20] in which 53% of 57 patients with heart failure scored less than 24 on the MMSE and were classified as cognitively impaired.

The similarity among studies in the percentage of the sample considered impaired is interesting because of the screening measures used. In our study, 4 screening measures were needed to detect cognitive impairment. However, in most other studies, a single measure was considered sufficient to detect problems in cognition. Had we used only the MMSE and the cutoff-point score used by others (<24), only 2.4% of the sample would have been suspected of being cognitively impaired. The difference between the percentage thought to be cognitively impaired in our study and the percentages in other studies that used the MMSE may be due to the education level of the participants. In the study by Cacciatore et al,[19] who

Table 3 Cognitively impaired participants: cognitive test scores and selected characteristics (n = 12)*

Raw and T-scores								
Commands subtest	**MMSE**	**Draw-a-Clock Test**	**Complex Ideational Material subtest**	**Serum osmolality, mOsm/L**	**Age, years**	**Education†**	**No. of medications**	**Time with heart failure**
4	28	2	10	300	71	3	8	18 months
19.55	47.29	53.81	46.43					
4	29	2	**8**	ND	79	4	5	16 months
19.55	53.62	53.81	**32.82**					
5	28	**1**	11	285	80	2	5	New
53.20	47.29	**30.93**	53.24					
5	30	**1**	11	274	83	3	10	2 years
53.20	59.95	**30.93**	53.24					
5	**22**	2	**8**	ND	72	1	10	10 years
53.20	**9.29**	53.81	**32.82**					
4	28	2	**7**	286	83	2	10	1 year
19.55	47.29	53.81	**26.01**					
5	26	**1**	10	295	83	3	6	19 months
53.20	**34.62**	**30.93**	46.43					
5	27	**1**	9	282	81	6	10	8 months
53.20	40.95	**30.93**	39.63					
5	29	**1**	**9**	ND	58	3	12	3 years
53.20	53.62	**30.93**	39.63					
5	27	**0**	**9**	306	48	2	8	1 year
53.20	40.95	**8.06**	39.63					
5	26	2	10	296	88	5	2	2.5 years
53.20	**34.62**	53.81	46.43					
4	27	2	**7**	298	82	3	8	5 months
19.55	40.95	53.81	**26.01**					

*Impaired cognition is defined as a T-score less than 35 on at least 1 of the cognitive measures; numbers in boldface indicate that the score was less than the cutoff point on that test. Dehydration is defined as serum osmolality of 295 mOsm/kg or greater. MMSE indicates Mini-Mental State Examination; ND, not done.
†Education: 1 = <7th grade, 2 = 8th grade, 3 = high school, 4 = business school, 5 = 2 years of college, 6 = 4 years of college.

detected cognitive impairment in 23% by using the MMSE, the mean level of education was less than 1 to 5 years of formal schooling. In our study, 80% of the participants had a high school education or more. Thus, our finding that only 2.4% (rather than 28.6%) of subjects were suspected to have cognitive impairment when only the MMSE was used may be due to the low sensitivity of the MMSE in detecting cognitive impairment in persons with moderate levels of education.[38]

In patients with heart failure, cognitive impairment may be intermittent or subtle in the early stages and thus not easily recognized. If so, routine screening is essential to ensure that cognitive impairment is detected and addressed as quickly as possible. In order to do so, practical, time-efficient, and sensitive measures are needed. In our study, only 1 patient had an MMSE raw score less than 24, but 11 others had evidence suggestive of cognitive impairment as indicated by 1 or more of the other cognitive tests. These findings suggest that the single score produced by the MMSE may be problematic, because information about possible deficits in memory may be lost when recall is delayed for 5 to 10 minutes. In this situation, memory deficits will not be detected when everything else is normal. Thus, the MMSE may not be the best clinical screening measure for patients with heart failure.

The highest percentage of patients with cognitive impairment was detected by using the Draw-a-Clock Test, and this test is simple to administer. A similar percentage of impaired patients was detected by using the Complex Ideational Material subtest, which is used to assess executive function abilities, but this test is time-consuming, requires training, and may not be useful in a busy critical care environment or for most research studies. Thus, we conclude that the Draw-a-Clock Test may be the best of the 4 measures for initial screening of patients with heart failure because it is easy to administer and readily indicates cognitive difficulties in these patients.

The observation that only 4 patients scored less than the T-score cutoff point in more than 1 test is

Table 4 Comparison of persons with a T-score of 35 or less versus persons with scores greater than 35 on any of the screening measures for cognitive impairment (N = 42)

Screening measure	Persons with scores ≤35 (n = 12)	Persons with scores >35 (n = 30)	*P*
Age, years, mean (SD)	75.7 (11.8)	74.3 (12.6)	.75
Female, % of patients	42	33	.37
Less than high school education, % of patients	33	13	.15
New York Heart Association functional class, mean (SD)	2.3 (0.1)	2.7 (0.7)	.16
Years with heart failure, mean (SD)	2.3 (2.7)	6.1 (6.2)	.06
No. of medical conditions, mean (SD)	3.5 (2.3)	3.2 (1.5)	.58
No. of routine medications, mean (SD)	7.8 (2.8)	8.3 (3.2)	.64
Fluid overload, % of patients	0	8	.53
Dehydrated, % of patients	55	44	.42

interesting and suggests that different aspects of cognition are detected with the 4 measures. Perhaps patients who are able to live independently in the community have early impairment of particular cognitive functions that is not detected by using either the Commands test or the MMSE, but is readily detected by screening with the Draw-a-Clock Test. Further research is needed to determine the best cognitive screening measure for patients with heart failure.

None of the 5 variables thought to be correlated with cognitive impairment was related, although the relationship between systolic blood pressure and cognitive impairment was in the expected direction and might have reached statistical significance with a larger sample size.[46] Surprisingly, age was not associated with an increase in possible cognitive impairment in this sample, even though a wide range of patients' ages was represented. We were surprised that neither fluid overload nor dehydration was a significant contributor to cognitive impairment in this sample of patients. Fluid shifts are common in patients with heart failure, and fluid overload is generally thought to be associated with cognitive impairment in heart failure.[27] Dehydration was thought to be an unrecognized contributor to the problem, but the results of this study lend no support to this hypothesis. Although we found that dehydration was present in almost half of the patients whose serum osmolality was measured, the hypothesis that dehydrated patients are more likely to be cognitively impaired was not supported.

This study was limited by the small sample size and the missing data on serum osmolality for some of the patients. Our results were strengthened, however, by the use of multiple measures of cognitive impairment because different aspects of cognitive impairment may have been detected. Although we tested 4 cognitive screening measures in this exploratory study, other tests may exist that should be assessed in future studies of cognition in patients with heart failure. Cognitive screening tools should be tested against a reference standard, such as a clinical neuropsychological battery, so that the sensitivity and specificity of simple measures for detecting cognitive impairment in patients with heart failure could be identified. Repeated measurement of cognition over time in future studies would help to determine if cognitive impairment in patients with heart failure is intermittent or chronic and progressive. If impairment is intermittent, modifiable factors may be able to be identified.

Further research into the factors associated with cognitive impairment in patients with heart failure is needed. Research to determine the iatrogenic factors and/or the factors amenable to intervention is particularly needed. Although hypotension and fluid shifts were not associated with cognitive impairment in our small sample of patients with heart failure, future studies with larger samples may yet reveal an association. Other possible mechanisms for cognitive impairment in patients with heart failure that warrant further study include depressed cardiac output, decreased cerebral perfusion, white matter lesions from silent cerebral infarction,[19] and increases in hemodynamic pressure (ie, pulmonary artery pressure and right atrial pressure).[22] Other factors known to be prevalent in patients with heart failure—depression, multiple medications, nutritional deficiencies—should also be explored as potential causes of cognitive impairment.

In summary, we found that cognitive impairment was present in 28.6% of our sample of community-dwelling patients with heart failure, but 4 tests had to be administered to detect the impairment. No single screening test of the 4 tested was sufficient to detect cognitive impairment in these patients, perhaps because the impairment is early, intermittent, or of a particular type. Our findings contribute to the growing body of literature indicating that cognitive impairment may be more common than previously thought in patients with heart failure. Future research should extend our knowledge about cognitive impairment associated with heart failure by exploring methods of measurement, associated factors, and interventions to prevent or manage this problem.

REFERENCES

1. *2000 Heart and Stroke Statistical Update.* Dallas, Tex: American Heart Association; 2001.
2. Happ MB, Naylor MD, Roe-Prior P. Factors contributing to rehospitalization for elderly patients with heart failure. *J Cardiovasc Nurs.* 1997;11:75-84.
3. Hoes AW, Mosterd A, Grobbee DE. An epidemic of heart failure? Recent evidence from Europe. *Eur J Cardiol.* 1998;19(suppl L):L2-L9.
4. Massie BM, Shah NB. Evolving trends in the epidemiologic factors of heart failure: rationale for preventive strategies and comprehensive disease management. *Am Heart J.* 1997;133:703-712.
5. *Population Projections of the United States, by Age, Sex, Race, and Hispanic Origin: 1993 to 2050.* Washington, DC: US Dept of Commerce; 1993. Publication P25-1104.
6. Huppert FA, Tym E. Clinical and neuropsychological assessment of dementia. *Br Med Bull.* 1986;42:11-18.
7. The Canadian Study of Health and Aging: study methods and prevalence of dementia. *Can Med Assoc J.* 1994;150:899-913.
8. Webster B. Recognition and treatment of dementing disorders in the elderly. *Clin Geriatr.* 1999;2:61-68.
9. Klein-Schwartz W, Oderda G. Poisoning in the elderly. *Drugs Aging.* 1991;1:67-89.
10. Borland C, Amadi A, Murphy P, Shallcross T. Biochemical and clinical correlates of diuretic therapy in the elderly. *Age Ageing.* 1986;15:357-363.
11. Cummings J. *Subcortical Dementia.* New York, NY: Oxford University Press; 1990.
12. Bostwick JM. The many faces of confusion: timing and collateral history often hold the key to diagnosis. *Postgrad Med.* 2000;108:60-62, 65-66, 71-72.
13. Holley H, Koslin D, Berland L, Stanley R. Inhomogeneous enhancement of liver parenchyma secondary to passive congestion: contrast-enhanced CT. *Abdom Gastrointest Radiol.* 1989;170:795-800.
14. Moulton J, Miller B, Dodd G, Vu D. Passive hepatic congestion in heart failure: CT abnormalities. *AJR Am J Roentgenol.* 1988;151:939-942.
15. Cosgray R, Davidhizar R, Giger J, Dreisl R. A program for water-intoxicated patients at a state hospital. *Clin Nurse Spec.* 1993;7:55-61.
16. Inouye S, Bogardus S, Charpentier P, et al. A multicomponent intervention to prevent delirium in hospitalized older patients. *N Engl J Med.* 1999; 340:669-676.
17. Lavizzo-Mourey RJ. Dehydration in the elderly: a short review. *J Natl Med Assoc.* 1987;79:1033-1038.
18. Warren JL, Bacon WE, Harris T, McBean AM, Foley DJ, Phillips C. The burden and outcomes associated with dehydration among US elderly, 1991. *Am J Public Health.* 1994;84:1265-1269.
19. Cacciatore F, Abete P, Ferrara N, et al. Congestive heart failure and cognitive impairment in an older population: Osservatorio Geriatrico Campano Study Group. *J Am Geriatr Soc.* 1998;46:1343-1348.
20. Zuccala G, Cattel C, Manes-Gravina E, Niro MD, Cocchi A, Bernabei R. Left ventricular dysfunction: a clue to cognitive impairment in older patients with heart failure. *J Neurol Neuosurg Psychiatry.* 1997;63:509-512.
21. Zuccala G, Onder G, Pedone C, et al. Hypotension and cognitive impairment: selective association in patients with heart failure. *Neurology.* 2001;57:1986-1992.
22. Putzke JD, Williams MA, Rayburn BK, Kirklin JK, Boll TJ. The relationship between cardiac function and neuropsychological status among heart transplant candidates. *J Card Fail.* 1998;4:295-303.
23. Almeida OP, Tamai S. Congestive heart failure and cognitive functioning amongst older adults. *Arq Neuropsiquiatr.* 2001;59:324-329.
24. Sauve MJ, Bennett SJ. Unrecognized cognitive deficits in chronic heart failure: the pilot [abstract]. *Circulation.* 1999;100(18 suppl):I-253.
25. Sauve MJ, Lewis W, Bennett SJ. Cognitive impairments, depression and medication compliance in patients with chronic heart failure [abstract]. *Circulation.* 2000;102(18 suppl):II-392.
26. Temple RO, Putzke JD, Boll TJ. Neuropsychological performance as a function of cardiac status among heart transplant candidates: a replication. *Percept Mot Skills.* 2000;91(3 Pt 1):821-825.
27. Bennett SJ, Pressler ML, Hays L, Firestine LA, Huster GA. Psychosocial variables and hospitalization in persons with chronic heart failure. *Progr Cardiovasc Nurs.* Fall 1997;12:4-11.
28. Staniforth AD, Kinnear WJM, Cowley AJ. Cognitive impairment in heart failure with Cheyne-Stokes respiration. *Heart.* 2001;85:18-22.
29. Bennett SJ, Huster GA, Baker SL, et al. Characterization of the precipitants of hospitalization for heart failure decompensation. *Am J Crit Care.* 1998;7:168-174.
30. Rich M, Keller A, Schechtman K, Marshall W, Kouchoukos N. Increased complications and prolonged hospital stay in elderly cardiac surgical patients with low serum albumin. *Am J Cardiol.* 1989;63:714-718.
31. Valero A, Alroy G, Eisenkraft B, Itskovitch J. Ammonia metabolism in chronic obstructive pulmonary disease with special reference to congestive right ventricular failure. *Thorax.* 1974;29:703-709.
32. Hou N, Bennett SJ, Eckert GJ, et al. Correlates of mental status in heart failure. *Circulation.* 2000;102(18 suppl):II-392.
33. Riegel B, Carlson B, Kopp Z, LePetri B, Unger A, Glaser D. Effect of a standardized nurse case-management telephone intervention on resource use in patients with chronic heart failure. *Arch Intern Med.* 2002;162:705-712.
34. Riegel B, Carlson B, Glaser D, Hoagland P. Which patients with heart failure respond best to multidisciplinary disease management? *J Card Fail.* 2000;6:290-299.
35. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;40:373-383.
36. Katz JN, Chang LC, Sangha O, Fossel AH, Bates DW. Can comorbidity be measured by questionnaire rather than medical record review? *Med Care.* 1996;34:73-84.
37. Ham RJ. Confusion, dementia, and delirium. In: Ham RJS, ed. *Primary Care Geriatrics: A Case-Based Approach.* 3rd ed. St Louis, Mo: CV Mosby; 1997:217-259.
38. McDowell I, Newell C. *Measuring Health: A Guide to Rating Scales and Questionnaires.* 2nd ed. New York, NY: Oxford University Press; 1996.
39. Goodglass H, Kaplan E. *The Assessment of Aphasia and Related Disorders.* Philadelphia, Pa: Lea & Febiger; 1983.
40. Folstein MF, Folstein SE, McHugh PR. "Mini-Mental State": a practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res.* 1975;12:189-198.
41. Fagerberg B, Ekman I, Skoog I. Cognitive impairment in elderly patients with chronic heart failure: occurrence and clinical implications [abstract]. *Circulation.* 1999;100(18 suppl):I-253.
42. Gennari FJ. Current concepts. Serum osmolality: uses and limitations. *N Engl J Med.* 1984;310:102-105.
43. Beers MH, Berkow R, eds. *The Merck Manual of Diagnosis and Therapy.* 17th ed. Whitehouse Station, NJ: Merck Research Laboratories; 1999.
44. Weinberg AD, Pals JK, McGlinchey-Berroth R, Minaker KL. Indices of dehydration among frail nursing home patients: highly variable but stable over time. *J Am Geriatr Soc.* 1994;42:1070-1073.
45. O'Neill PA, Faragher EB, Davies I, Wears R, McLean KA, Fairweather DS. Reduced survival with increasing plasma osmolality in elderly continuing-care patients [published erratum appears in *Age Ageing.* 1990;19:346-347] [see comments]. *Age Ageing.* 1990;19:68-71.
46. Brown JK, Porter LA, Knapp TR. The applicability of sequential analysis to nursing research. *Nurs Res.* 1993;42:280-282.

AJCC American Journal of Critical Care

Evidence-based interdisciplinary knowledge for high acuity and critical care

Cognitive Impairment in Heart Failure: Issues of Measurement and Etiology

Barbara Riegel, Jill A. Bennett, Andra Davis, Beverly Carlson, John Montague, Howard Robin and Dale Glaser

Am J Crit Care 2002;11 520-528

Published online http://ajcc.aacnjournals.org/