# Medicare Patients with Cardiovascular Disease Have a High Prevalence of Chronic Kidney Disease and a High Rate of Progression to End-Stage Renal Disease

WILLIAM M. MCCLELLAN,*†‡ ROBERT D. LANGSTON,* and RODNEY PRESLEY*
*Georgia Medical Care Foundation, Atlanta, Georgia; †Rollins School of Public Health, Emory University, Atlanta, Georgia; and ‡Division of Kidney Disease, Emory University, Atlanta, Georgia*

*Abstract.* The risk of progression to ESRD among individuals with cardiovascular disease and chronic kidney disease (CKD) is not well defined. The purpose of this study was to describe the risk of ESRD among patients with cardiovascular disease. Charts were abstracted for randomly selected hospitalized Medicare beneficiaries with a diagnosis of either congestive heart failure (CHF) or acute myocardial infarction (AMI). The prevalence of CKD, based on the estimated modified diet in renal disease GFR of $<60$ ml/min per $m^2$, was 60.4% of CHF patients and 51.7% of AMI patients. When compared with patients without CKD, the 30-d readmission rate was higher for CHF patients with CKD (odds ratio [OR], 1.70; 95% confidence interval [CI], 1.18 to 2.44) and for AMI patients with CKD (OR, 1.78; 95% CI, 1.17 to 2.70). CHF patients (OR, 1.62; 95% CI, 1.15 to 2.30) and AMI patients (OR, 3.10; 95% CI, 1.98 to 4.84) with CKD were more likely to die during the year after discharge from the hospital. ESRD after discharge occurred in nine of 517 patients with AMI and 24 of 640 patients with CHF. CKD increased the risk of ESRD among CHF patients (OR, 34.5; 95% CI, 4.23 to 279.43) and AMI patients (0 and 3% for those without and with CKD, respectively). At discharge, 18% of AMI patients and 21% of CHF patients with CKD were discharged with a diagnosis of renal disease. CKD is highly prevalent among patients with cardiovascular disease and is associated with increased risk of adverse outcomes, including progression to ESRD. This study suggests that opportunities may exist to improve the detection of CKD in these patients who are hospitalized with cardiovascular disease.

ESRD is the consequence of progressive chronic kidney disease (CKD). When CKD is detected, interventions, summarized in clinical practice guidelines, can delay or prevent the progression of renal injury (1–4). Despite dissemination of these guidelines, there is evidence that CKD is neither detected early nor treated in accordance with guideline-based recommendations (5–7). It has been suggested that routine screening of groups that are at high risk for renal injury might improve the identification and treatment of CKD. High-risk populations that have been identified include individuals with diabetes and hypertension, minority populations, the elderly, and individuals who use nonsteroidal anti-inflammatory agents (1,8).

Patients with cardiovascular disease may also warrant inclusion in this list of high-risk populations. Studies that examine the association between CKD and risk of death from cardiovascular disease have reported high prevalence of CKD among patients with cardiovascular disease (9–21). It is not clear, however, that patients with both cardiovascular disease and CKD are at increased risk of ESRD. For example, we have previously reported that CKD is highly prevalent among Medicare beneficiaries who are admitted to the hospital with either myocardial infarction or heart failure and that cardiovascular disease confers increased risk of death in this patient population (22,23). Thus, it is possible that intervening mortality might occur before the onset of ESRD among patients with cardiovascular disease. In this report, we examine the occurrence of ESRD among these Medicare beneficiaries after a hospitalization for either heart failure or acute myocardial infarction (AMI).

## Materials and Methods

We conducted a cohort study of randomly selected patients who were discharged from community hospitals with a primary diagnosis of AMI or congestive heart failure (CHF).

### *Study Population*

We conducted analyses on two populations of patients. One population consisted of Medicare fee-for-service patients with a primary diagnosis of AMI. The second population consisted of Medicare fee-for-service patients with the primary diagnosis of CHF. Patients in both samples consisted of a random sample of Medicare beneficiaries who had the appropriate *International Classification of Diseases, 9th Revision* (ICD-9) codes and were admitted to any general hospital in a single southeastern state between July 1, 1998, and December 31, 1998, and who were alive at discharge. Patients with heart failure were identified with a principal diagnosis ICD-9 code of 402.01,

Received October 9, 2003. Accepted April 13, 2004.
Correspondence to Dr. William McClellan, Georgia Medical Care Foundation, 1455 Lincoln Parkway, Suite 800, Atlanta, GA 30346. Phone: 678-527-3473; Fax: 678-527-3030; E-mail: bmcclellan@gmcf.org
1046-6673/1507-1912
Journal of the American Society of Nephrology

DOI: 10.1097/01.ASN.0000129982.10611.4C

402.11, 402.91, 404.01, 404.11, 404.91, and 428.xx. Patients with AMI were identified with a principal diagnosis code of 410.xx of the *International Classification of Diseases, 9th Revision, Clinical Modification.*

### *Exclusions*

Patients who were enrolled in Medicare managed care plans were excluded from the sample. Patients were excluded when they had a history of renal disease identified as a history of chronic dialysis in the medical record or a serum creatinine in excess of 6 mg/dl. We also excluded patients who died before discharge ($n = 24$ for CHF and $n = 68$ for AMI) and patients for whom we could find no record of their survival status after discharge in the Medicare status file ($n = 20$ for CHF and $n = 16$ for AMI).

### *Data Abstraction*

Records for eligible patients were identified by the Medicare Medical Information System, and a random sample of eligible discharges was chosen for each condition. Trained medical record abstractors used a standardized form to abstract patient charts. Abstraction was done at a central center, and abstractors were blinded to the study purpose. A random selection of charts in both populations were re-abstracted to ensure accurate data abstraction. Data abstracted for each patient included date of admission and discharge, demographic information (age, race, and gender), and degree of mobility on discharge. Comorbid conditions, as recorded by the clinician, that were abstracted included a history of stroke, previous myocardial infarction, heart failure, diabetes, and hypertension. Laboratory data abstracted from each chart included serum creatinine. We used the first recorded value for laboratory tests to reduce the possibility of bias by indication for laboratory testing.

### *Follow-up*

Follow-up for patients who were admitted to either the AMI or the CHF cohort between July 1, 1998, and December 31, 1998, began on the date of discharge from the hospital for the index admission and continued until March 1, 2002. Patients were characterized as dead when a date of death had been recorded for them in the Medicare Enrollment Database and as missing when neither a date of death nor a current Medicare eligibility record was found. We were unable to identify either a death date or evidence for current eligibility for 16 (2.5%) of the patients in the AMI cohort and 20 (2.8%) in the CHF cohort, and these patients were excluded from mortality analyses. We determined the occurrence of a readmission to the hospital by identifying patients who had an inpatient claim in the National Medicare Claims database during either the 30 d or 1 yr after discharge.

We defined CKD as a modified diet in renal disease (MDRD) estimated GFR of $<60$ ml/min per 1.73 $m^2$. We determined the occurrence of ESRD by identifying patients who had no diagnosis for ESRD in the Inpatient Standard Analytic Tables data set during 1998 and who were identified subsequently in 1999, 2000, or 2001 as being treated for ESRD. A limitation of the Inpatient Standard Analytic Tables data set is that it identifies patients by their year of enrollment in the Medicare ESRD but does not provide a day and month of enrollment.

### *Statistical Analyses*

We calculated descriptive statistics, 30-d readmission rates, the 12-mo risk of death, and cumulative occurrence of ESRD for each cohort. Adjusting for age, race, and gender with logistic regression, we used odds ratios (OR) and associated confidence intervals (CI) to measure the association between categorical variables and CKD. All analyses were conducted using SAS Version 8.12 (SAS Institute, Cary, NC) and Epi Info Version 6 Stat Calculator.

## Results

A total of 709 patients were admitted to community hospitals with AMI, and 755 patients were admitted for CHF. This sample represented 17% of all AMI patients and 9% of all CHF patients who were Medicare beneficiaries in the state during the entrance time period. After excluding duplicate records of patients with subsequent admissions within the entry time period in both cohorts (AMI = 63, CHF = 40), patients with creatinine $>6.0$ (AMI = 11, CHF = 1), patients who died before discharge (AMI = 64, CHF = 25), patients who were lost to follow-up (AMI = 16, CHF = 20), and patients with a history of renal disease (AMI = 3, CHF = 7), data from 552 AMI patients and 662 CHF patients were analyzed. Records of patients from 101 hospitals were used in the AMI analysis and from 120 hospitals in the CHF analysis.

The characteristics of both patient populations are shown in Table 1. The mean (SD) age of the AMI cohort was 73.8 yr (10.0), with a range from 32 to 98 yr and a 25th to 75th interquartile range from 68 to 80 yr. Similarly, for CHF patients, the mean (SD) age was 75.7 yr (10.9), with a range from 30 to 100 yr and a 25th to 75th interquartile range from 70 to 83 yr. Patients who were admitted for AMI were younger, more likely to be male, and white compared with patients in the CHF cohort. Patients with AMI were more likely to report a history of hypertension and less likely to report one of diabetes than were CHF patients.

CKD was highly prevalent among patients in the AMI cohort. A serum creatinine value was reported on admission for 522 (95%) of the AMI cohort, and the mean (SD) value was 1.35 (0.74) mg/dl (Figure 1). A GFR calculated using the MDRD equation was available for 518 (94%) of the AMI cohort. The mean (SD) GFR was 60.6 (26.8) ml/min per 1.73 $m^2$ (Figure 2). CKD was present in 51.7% of AMI patients. The mean (SD) GFR among individuals with CKD was 42.3 (13.1) ml/min per 1.73 $m^2$ and among those without CKD was 80.2 (23.6) ml/min per 1.73 $m^2$ ($P < 0.001$).

Similarly, CKD was highly prevalent among patients who were hospitalized with CHF. A serum creatinine value was reported on admission for 643 (97%) of the CHF cohort, and the mean (SD) value was 1.45 (0.75) mg/dl (Figure 1). A GFR calculated using the MDRD equation was available for 627 (95%) of the CHF cohort. The mean (SD) GFR was 55.7 (24.7) ml/min per 1.73 $m^2$ (Figure 2). CKD was present in 60.4% of CHF patients. The mean (SD) GFR among individuals with CKD was 39.7 (12.9) ml/min per 1.73 $m^2$ and among those without CKD was 80.2 (17.3) ml/min per 1.73 $m^2$ ($P < 0.001$).

Mortality rates were high, with 24% of AMI and 37% of CHF patients dying during the first year of follow-up. The presence of CKD was associated with an increased risk of death (Table 2) among patients who were discharged with CHF and AMI. The presence of CKD increased the risk of death within the first year for CHF patients (OR, 1.62; 95% CI, 1.15 to 2.30) and AMI patients (OR, 3.10; 95% CI, 1.98 to 4.84). Readmission to the hospital within 30 d and during the first

*Table 1.* Characteristics of patients with AMI and CHF[a]

| Characteristic | AMI (*n* [%]) | CHF (*n* [%]) |
|---|---|---|
| Age (yr) | | |
| ≤70 | 157 (30.1) | 165 (25.7) |
| 71–75 | 116 (22.2) | 110 (17.1) |
| 76–80 | 111 (21.3) | 126 (19.6) |
| >80 | 138 (26.4) | 242 (37.6) |
| Gender | | |
| male | 267 (51.2) | 256 (39.8) |
| female | 255 (48.9) | 387 (60.2) |
| Race | | |
| white | 422 (80.8) | 452 (70.3) |
| black | 96 (18.4) | 175 (27.2) |
| Previous MI | 183 (35.1) | 174 (27.1) |
| Comorbidity | | |
| stroke | 98 (18.8) | 128 (19.9) |
| CHF | 126 (24.1) | 482 (75.0) |
| high BP | 373 (71.5) | 427 (66.4) |
| diabetes | 174 (33.3) | 282 (43.9) |
| Functional impairment | | |
| normal | 182 (34.9) | 278 (43.2) |
| mild | 197 (37.7) | 200 (31.1) |
| moderate | 93 (17.8) | 147 (22.9) |
| severe | 50 (9.6) | 18 (2.8) |
| Hematocrit | | |
| ≥40% | 234 (44.8) | 191 (29.7) |
| 36–39% | 130 (24.9) | 143 (22.2) |
| 30–35% | 113 (21.6) | 205 (31.8) |
| <30% | 26 (5.0) | 84 (13.1) |
| Albumin <3.5 g/dl | 110 (21.1) | 219 (34.1) |
| Serum creatinine (mg/dl) | | |
| 0–1.0 | 201 (38.5) | 215 (33.4) |
| 1.1–2.0 | 260 (49.8) | 330 (51.3) |
| 2.1–3.0 | 43 (8.2) | 70 (10.9) |
| >3.0 | 18 (3.4) | 28 (4.4) |

[a] AMI, acute myocardial infarction; CHF, congestive heart failure.

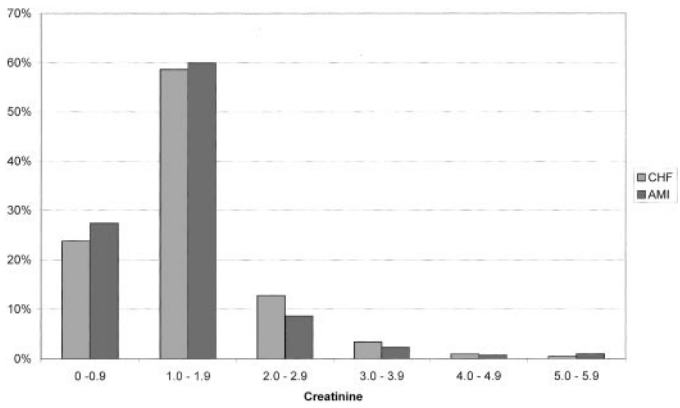


*Figure 1.* Distribution of serum creatinine levels by disease.

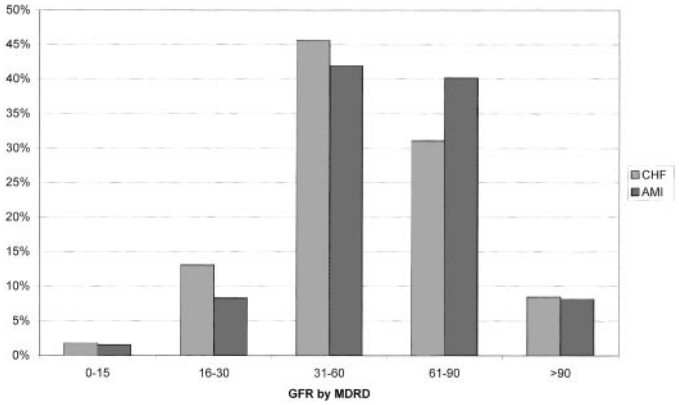


*Figure 2.* Distribution of GFR levels by disease.

year after discharge for the index admission was also high in both AMI and CHF patients (Table 2). The presence of CKD increased the risk of early readmission for both CHF patients (OR, 1.70; 95% CI, 1.18 to 2.44) AMI patients (OR, 1.78; 95% CI, 1.17 to 2.70).

During the calendar year after discharge, 1.0% of AMI patients and 2.1% of CHF patients developed a diagnosis of ESRD. The presence of CKD greatly increased the risk of ESRD developing within 1 yr of discharge. Among CHF patients with CKD, 3.5% developed ESRD compared with 0.0% of those without CKD (OR not defined). Among AMI patients with CKD, 1.9% developed ESRD compared with 0.0% of those without CKD (OR not defined). When we used the alternative definition of CKD based on serum creatinine >1.4 mg/dl for women and 1.5 mg/dl for men, we obtained similar results.

We examined the risk of progression to ESRD during follow-up among patients with moderate and severe CKD. Figures 3 and 4 show the proportion of patients who progressed to ESRD by level of serum creatinine (Figure 3) and estimated GFR (Figure 4), and it is evident that risk of ESRD occurred over a broad range of either serum creatinine or GFR. As can be seen in both figures, most of those who developed ESRD had an estimated GFR <30 ml/min per $m^2$. Of note was that 50% of patients who progressed to ESRD during follow-up had a serum creatinine of 2.5 mg/dl or less (Figure 3).

When the serum creatinine was used to define CKD, 29 of 33 patients who developed ESRD were identified as having CKD, a test sensitivity of 88% and a specificity of 68% (Table 3). In contrast, only one of 32 patients who progressed to ESRD had a GFR >60 ml/min per $m^2$, a diagnostic sensitivity of 97% and a specificity of 45%. When a GFR cutpoint of 30 ml/min per $m^2$ is used to identify those who eventually progressed to ESRD, the diagnostic sensitivity of the MDRD GFR was 72% and specificity was 89%.

We also examined the proportion of individuals who developed ESRD during follow-up and had a discharge diagnosis of chronic CKD, as defined by ICD-9 codes 582.0 to 582.9, 585.0 to 588.9, and 593.9. Many of those patients who progressed to ESRD did not have diagnosis of CKD at discharge. Table 4 shows the proportion of patients with a discharge diagnosis of CKD by level of GFR. Even at the most severe degrees of impaired renal

*Table 2.* Patient outcome after discharge[a]

| Characteristic | AMI | | | CHF | | |
|---|---|---|---|---|---|---|
| | No CKD ($N$ = 250; %) | CKD ($N$ = 268; %) | OR[b] (95% CI) | No CKD ($N$ = 248; %) | CKD ($N$ = 379; %) | [b]OR (95% CI) |
| Dead 12 mo | 34 (13.6) | 92 (34.3) | 3.10 (1.98 to 4.84) | 73 (29.4) | 158 (41.7) | 1.62 (1.15 to 2.30) |
| Readmission 30 d | 50 (20.0) | 79 (29.5) | 1.78 (1.17 to 2.70) | 64 (25.8) | 137 (36.2) | 1.70 (1.18 to 2.44) |
| ESRD | | | | | | |
| ESRD in 1999 | 0 (0.0) | 5 (1.9) | N/A | 0 (0.0) | 13 (3.5) | N/A |
| New-onset ESRD | 0 (0.0) | 8 (3.0) | N/A | 1 (0.4) | 23 (6.1) | 34.5 (4.23 to 279.43) |

[a] CKD, chronic kidney disease; OR, odds ratio; CI, confidence interval.
[b] Adjusted for age, race, and gender using logistic regression.




*Figure 3.* Cumulative proportion of ESRD by serum creatinine.

function, MDRD estimated GFR of <30 ml/min per $m^2$, fewer than half of these patients had a diagnosis of CKD.

The likelihood that individuals who developed ESRD during follow-up would have a discharge diagnosis of CKD at discharge for both CHF and AMI patients was low. Among the 24 CHF patients who were treated for ESRD during follow-up, 20% were discharged with a recorded diagnosis of CKD, and among the 10 AMI patients who developed ESRD, 20% had a diagnosis of CKD at discharge.

## Discussion

Our major findings are that patients who are admitted to the hospital for cardiovascular disease are at high risk for prevalent CKD and that a substantial proportion of these patients progress to ESRD treatment within a short period. These results support the concept that patients with cardiovascular disease should be recognized as a group at high risk for ESRD and suggest that a pragmatic approach to improving the identification and care of patients with CKD might include programs targeted to these patients with cardiovascular disease.

The occurrence of ESRD that we observed is far in excess of what we expected on the basis of the rates published by the U.S. Renal Data System for comparable age groups in the U.S. population (22). For example, the incidence for the U.S. population aged 75 yr and older in 2000, unadjusted for other demographic characteristics, was 1349 cases per million people and, after accounting for gender, race, and primary cause of ESRD, 1543 cases per million (22). This translates to an annual rate of 0.13 to 0.15 cases per 100 people. In contrast to these expected rates, we observed 1.16 new cases of ESRD per 100 patients who were hospitalized for an AMI and two new cases per 100 patients who were hospitalized for CHF during the year after the index admission.

This report is the first, to our knowledge, to report that Medicare beneficiaries with either ischemic heart disease or heart failure are high-risk populations for ESRD. It is consistent with estimates for the risk of ESRD among individuals with cardiovascular disease in the general population made by Muntner *et al.* (23). They used the Second and Third National Health and Nutrition Examination Survey studies to estimate the prevalence of

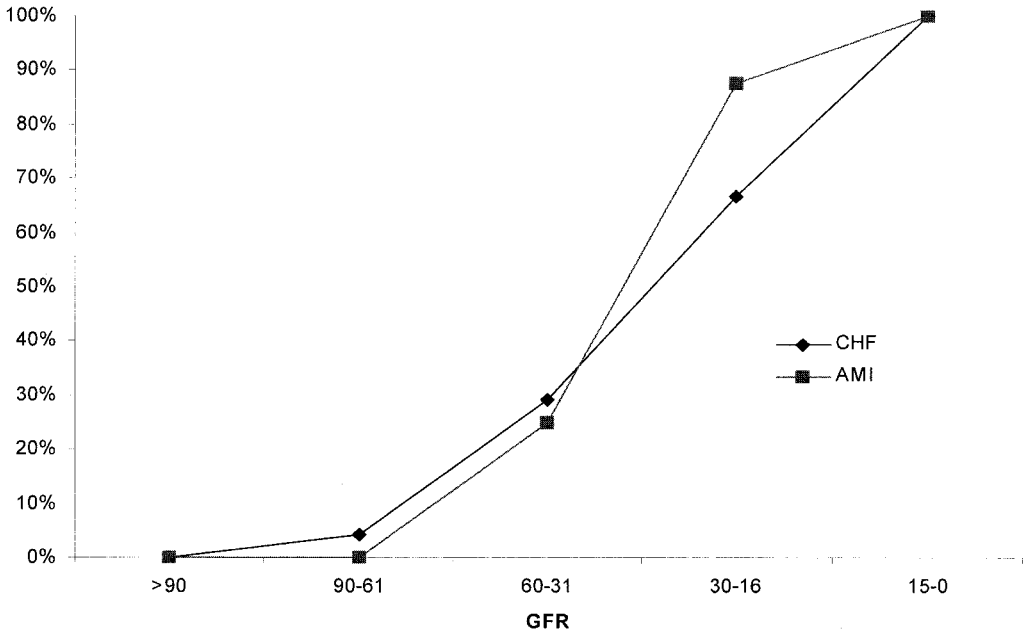


*Figure 4.* Cumulative proportion of ESRD by GFR.

*Table 3.* Risk of ESRD by level of CKD[a]

| Test | ESRD | | % | Test Characteristics of Cutpoint | |
|---|---|---|---|---|---|
| | Yes | No | | Sensitivity | Specificity |
| Serum creatinine[b] | | | | | |
| CKD | 29 | 357 | 8% | 88% | 68% |
| no CKD | 4 | 775 | 0.5% | | |
| MDRD ≤60 ml/min per $m^2$ | | | | | |
| yes | 31 | 616 | 5% | 97% | 45% |
| no | 1 | 497 | 0.2% | | |
| MDRD ≤30 ml/min per $m^2$ | | | | | |
| yes | 23 | 121 | 19% | 72% | 89% |
| no | 9 | 992 | 0.9% | | |

[a] MDRD, modified diet in renal disease.
[b] Serum creatinine cutpoints for CKD were 1.4 mg/dl for women and 1.5 mg/dl for men.

*Table 4.* Diagnosis of any renal disease by GFR[a]

| GFR | GFR >90 | GFR = 61–90 | GFR = 30–60 | GFR <30 |
|---|---|---|---|---|
| AMI (*n*) | 42 | 211 | 219 | 53 |
| % Dx CKD | 0.0% | 1.0% | 12.8% | 39.6% |
| CHF (*n*) | 54 | 195 | 287 | 94 |
| % Dx CKD | 0.0% | 1.0% | 13.2% | 43.6% |

[a] Dx, diagnosis.

cardiovascular disease, defined as a history of myocardial infarction or stroke, to define the number of individuals in the U.S. population with cardiovascular disease. Similar estimates were made for diabetes. They estimate that the incidence of ESRD among individuals with cardiovascular disease in the U.S. population is 1463 per million people. A comparable estimate for the rate of ESRD among individuals with diabetes, regardless of other conditions, including cardiovascular disease, was 2567 per million people. The estimated rate for the population with neither condition was 153 per million (23). It should be noted that analyses by Muntner *et al.* are not based on direct observations of the populations at risk and therefore are subject to all of the limitations of an ecologic analysis.

There is other evidence to support the possibility that cardiovascular disease increases the risk of ESRD. Perry *et al.* (24) observed that risk of ESRD among hypertensive men was independently associated with a new onset of myocardial infarction (relative risk, 1.96; 95% CI, 1.19 to 3.22) and new onset of heart failure (relative risk, 5.39; 95% CI, 3.87 to 7.52) during follow-up. Furthermore, the prevalence of atherosclerotic cardiovascular disease among incident ESRD patients is higher than that observed for other causes of ESRD, and, after controlling for other characteristics, patients with hypertensive ESRD were more likely to have a diagnosis of angina or atherosclerosis (25). These observations suggest that atherosclerosis is a risk factor for progressive chronic renal failure among individuals with hypertension and are consistent with the high rate of ESRD noted among our patients during follow-up.

Although it is not unexpected that patients with both cardiovascular disease and CKD might progress to ESRD, the rapidity and the magnitude of this risk were unexpected. Furthermore, many of the patients who developed ESRD had normal to modestly increased serum creatinine levels, which, if not converted to an estimated GFR or creatinine clearance, as has been recommended by recent clinical practice guidelines, might not alert clinicians to the degree of impaired renal function. This point is strengthened by the observation that a majority of cardiovascular disease patients who progressed to ESRD had an estimated GFR of 30 ml/min per $m^2$ or below in contrast to the substantial proportion who progressed to ESRD despite only modest elevations of serum creatinine.

What is the clinical relevance of our observations beyond calling the attention of clinicians to the high risk of CKD and ESRD among elderly cardiovascular disease patients? Our analysis is based on data used in a program conducted by the Centers for Medicare and Medicaid Services (CMS). This program is called the Health Care Quality Improvement Program (HCQIP), and it is designed to improve the care of Medicare beneficiaries with cardiovascular disease (26). The HCQIP routinely collects and reports data about the quality of medical care and then links the information to a quality of care improvement intervention (27,28). We are implementing a pilot HCQIP program that extends these quality improvement efforts targeted at hospitals and clinicians to interventions to improve detection and management of care of CKD among patients with cardiovascular disease (29,30).

Several limitations to our study should be noted. First, we excluded managed care patients from our analysis because of limited availability of follow-up data. We believe that this is reasonable as the penetration on Medicare managed care programs in Georgia is small. Second, our data were abstracted to investigate the care of cardiovascular disease among Medicare patients, rather than to study CKD in these patients. Thus, important information about the care of these patients, such as referral to a nephrologist after admission, is unavailable to us. Furthermore, a more detailed analysis of risk factors associated with the occurrence of ESRD is in order. However, the small numbers of ESRD cases in our single-state sample precludes any extensive analysis using this data set. We used a single, within-hospital serum creatinine as a measure of CKD. It is possible that individuals who were categorized as having CKD by this method may have experienced disease- or treatment-related elevations in their serum creatinine with subsequent return to normal renal function. This could result in inclusion of patients at otherwise lower risk of developing ESRD in our CKD population and would tend to diminish the observed risk. Studies with serial measurements of renal function in larger cohorts are needed to define better the true magnitude of risk for ESRD experienced among elderly patients with cardiovascular disease.

Our analysis of the association between the presence of a diagnosis of CKD and the level of estimated GFR suggests that there may be underrecognition of even advanced kidney disease. Because our definition was based on discharge diagnoses, it is possible that substantially higher rates of recognition of CKD may have occurred during these hospitalizations. Mitigating this possibility is the increasing frequency of a CKD diagnosis with decreasing estimated GFR, which suggests that clinicians may be relying on elevated serum creatinine rather than estimated GFR to diagnose kidney disease.

It is also important to realize that our observations are limited primarily to elderly and cannot be generalized directly to younger populations. The 65 yr and older age group is not an insignificant population for the ESRD program, with 49% of incident ESRD patients in 2000 falling into this age group (22). Also relevant to this issue are the observations by Muntner *et al.* (23), who reported age-specific estimates for ESRD risk among prevalent cardiovascular patients in the U.S. population. Our patient level observations are consistent with the high rates of ESRD incidence reported by Muntner *et al.* for populations aged 65 yr and older. They also reported similar increased risk of ESRD among younger patients with cardiovascular disease, and we expect that this prediction will also be supported by patient-level observations. Finally, as this study was limited to a representative sample of a single state, extrapolation of our results to other states awaits analysis of the national data set.

In conclusion, CKD is highly prevalent and may be poorly identified in a representative sample of Medicare beneficiaries with cardiovascular disease in a single southern state. Individuals with cardiovascular disease and CKD have a high risk of progression to ESRD. If similar patterns of care occur in other states, then systematic efforts to improve CKD care of this patient population should be developed and implemented. Data are available to assess this issue further, and existing CMS programs could be used to deliver interventions to help physicians and allied health care providers develop CKD quality improvement efforts in their hospitals.

## Acknowledgments

The analyses on which this publication is based were performed under Contract No. 500-96-P704, entitled Operation Utilization and Quality Control Peer Review Organization (PRO) for the State of Georgia, and sponsored by the CMS, Department of Health and Human Services. The conclusions and opinions expressed and methods used herein are those of the authors. They do not necessarily reflect CMS policy. The authors assume full responsibility for the accuracy and completeness of the ideas presented. This article is a direct result of the Health Care Quality Improvement Program initiated by CMS, which has encouraged identification of quality improvement projects derived from analysis of patterns of care, and therefore required no special funding on the part of this contractor. Ideas and contributions to the authors concerning experience in engaging with issues presented are welcomed.

## References

1. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Kidney Disease Outcome Quality Initiative. *Am J Kidney Dis* 39[Suppl 2]: S1–246, 2002
2. American Diabetes Association diabetic nephropathy, position statement. Clinical practice recommendations. *Diabetes Care* 25: 585–589, 2002
3. 1995 update of the working group reports on chronic renal failure and renovascular hypertension. National High Blood Pressure Education Program Working Group. *Arch Intern Med* 156: 1938–1947, 1996
4. Keane WF, Eknoyan G: Proteinuria, albuminuria, risk, assessment, detection, elimination (PARADE): Position paper of the National Kidney Foundation. *Am J Kidney Dis* 33: 1004–1010, 1999
5. McClellan WM, Knight DF, Karp H, Brown WW: Early detection and treatment of renal disease in hospitalized diabetic and hypertensive patients: Important differences between practice and published guidelines. *Am J Kidney Dis* 29: 368–375, 1997
6. Kraft SK, Lazaridis EN, Qiu C, Clark CM Jr, Marrero DG: Screening and treatment of diabetic nephropathy by primary care physicians. *J Gen Intern Med* 14: 88–97, 1999
7. Wong T, Foote EF, Lefavour GS, Cody RP, Brown CJ, Sherman RA: Physician knowledge and practice patterns relating to diabetic nephropathy. *J Am Pharm Assoc (Wash)* 39: 785–790, 1999
8. McClellan WM, Ramirez SBP, Jurkovitz C: Screening for chronic kidney disease: Unresolved issues. *J Am Soc Nephrol* 14[Suppl 2]:S81–S87, 2003
9. Matts JP, Karnegis JN, Campos CT, Fitch LL, Johnson JW, Buchwald H: Serum creatinine as an independent predictor of coronary heart disease mortality in normotensive survivors of myocardial infarction. POSCH Group. *J Fam Pract* 36: 497–503, 1993
10. Wright RS, Reeder GS, Herzog CA, Albright RC, Williams BA, Dvorak DL, Miller WL, Murphy JG, Kopecky SL, Jaffe AS: Acute myocardial infarction and renal dysfunction: A high-risk combination. *Ann Intern Med* 137: 563–570, 2002
11. Shlipak MG, Heidenreich PA, Noguchi H, Chertow GM, Browner WS, McClellan MB: Association of renal insufficiency with treatment and outcomes after myocardial infarction in elderly patients. *Ann Intern Med* 137: 555–562, 2002
12. Reis SE, Olson MB, Fried L, Reeser V, Mankad S, Pepine CJ, Kerensky R, Merz CN, Sharaf BL, Sopko G, Rogers WJ, Holubkov R: Mild renal insufficiency is associated with angiographic coronary artery disease in women. *Circulation* 105: 2826–2829, 2002
13. Best PJ, Lennon R, Ting HH, Bell MR, Rihal CS, Holmes DR, Berger PB: The impact of renal insufficiency on clinical outcomes in patients undergoing percutaneous coronary interventions. *J Am Coll Cardiol* 39: 1113–1119, 2002
14. Anderson RJ, O'Brien M, MaWhinney S, VillaNueva CB, Moritz TE, Sethi GK, Henderson WG, Hammermeister KE, Grover FL, Shroyer AL: Renal failure predisposes patients to adverse outcome after coronary artery bypass surgery. VA Cooperative Study #5. *Kidney Int* 55: 1057–1062, 1999
15. Szczech LA, Best PJ, Crowley E, Brooks MM, Berger PB, Bittner V, Gersh BJ, Jones R, Califf RM, Ting HH, Whitlow PJ, Detre KM, Holmes D: Outcomes of patients with chronic renal insufficiency in the bypass angioplasty revascularization investigation. *Circulation* 105: 2253–2258, 2002
16. Mann JF, Gerstein HC, Pogue J, Bosch J, Yusuf S: Renal insufficiency as a predictor of cardiovascular outcomes and the impact of ramipril: The HOPE randomized trial. *Ann Intern Med* 134: 629–636, 2001
17. Tonelli M, Moye L, Sacks FM, Kiberd B, Curhan G: Pravastatin for secondary prevention of cardiovascular events in persons with mild chronic renal insufficiency. *Ann Intern Med* 138: 98–104, 2003
18. Culleton BF, Larson MG, Wilson PW, Evans JC, Parfrey PS, Levy D: Cardiovascular disease and mortality in a community-based cohort with mild renal insufficiency. *Kidney Int* 56: 2214–2219, 1999
19. Shlipak MG, Fried LF, Crump C, Bleyer AJ, Manolio TA, Tracy RP, Furberg CD, Psaty BM: Cardiovascular disease risk status in elderly persons with renal insufficiency. *Kidney Int* 62: 997–1004, 2002
20. Muntner P, He J, Hamm L, Loria C, Whelton PK: Renal insufficiency and subsequent death resulting from cardiovascular disease in the United States. *J Am Soc Nephrol* 13: 745–753, 2002
21. Manjunath G, Tighiouart H, Coresh J, Macleod B, Salem DN, Griffith JL, Levey AS, Sarnak MJ: Level of kidney function as a risk factor for cardiovascular outcomes in the elderly. *Kidney Int* 63: 1121–1129, 2003
22. U.S. Renal Data System: *USRDS 2002 Annual Data report: Atlas of End-Stage Renal Disease in the United States*, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 2002
23. Muntner P, Coresh J, Powe NR, Klag MJ: The contribution of increased diabetes prevalence and improved myocardial infarction and stroke survival to the increase in treated end-stage renal disease. *J Am Soc Nephrol* 14: 1568–1577, 2003
24. Perry HM Jr, Miller JP, Fornoff JR, Baty JD, Sambhi MP, Rutan G, Moskowitz DW, Carmody SE: Early predictors of 15-year end-stage renal disease in hypertensive patients. *Hypertension* 25[Suppl]:587–594, 1995
25. Bleyer AJ, Chen R, D'Agostino RB Jr, Appel RG: Clinical correlates of hypertensive end-stage renal disease. *Am J Kidney Dis* 31: 28–34, 1998
26. Jencks SF, Wilensky GR: The health care quality improvement initiative. A new approach to quality assurance in Medicare. *JAMA* 268: 900–903, 1992

27. Jencks SF, Cuerdon T, Burwen DR, Fleming B, Houck PM, Kussmaul AE, Nilasena DS, Ordin DL, Arday DR: Quality of medical care delivered to Medicare beneficiaries: A profile at state and national levels. *JAMA* 284: 1670–1676, 2000
28. Jencks SF, Huff ED, Cuerdon T: Change in the quality of care delivered to Medicare beneficiaries, 1998–1999 to 2000–2001. *JAMA* 289: 305–312, 2003
29. McClellan WM, Flanders WD, Langston RD, Jurkovitz C, Presley R: Anemia and renal insufficiency are independent risk factors for death among patients with congestive heart failure admitted to community hospitals: A population-based study. *J Am Soc Nephrol* 13: 1928–1936, 2002
30. Langston RD, Presley R, Flanders WD, McClellan WM: Renal insufficiency and anemia are independent risk factors for death among patients with acute myocardial infarction. *Kidney Int* 64: 1398–1405, 2003