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Acute Myocardial Infarction in the Elderly: Differences by Age

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OBJECTIVES We evaluated the clinical characteristics and outcomes of elderly patients hospitalized with acute myocardial infarction (AMI) to describe differences by age.

BACKGROUND Elderly patients with AMI are perceived as a homogeneous population, though the extent by which clinical characteristics vary among elderly patients has not been well described.

METHODS Data from 163,140 hospital admissions of Medicare beneficiaries age ≥65 years between 1994 and 1996 with AMI at U.S. hospitals were evaluated for differences in clinical characteristics and mortality across five age-based strata (in years): 65 to 69, 70 to 74, 75 to 79, 80 to 84 and ≥85.

RESULTS Older age was associated with a greater proportion of patients with functional limitations, heart failure, prior coronary disease and renal insufficiency and a lower proportion of male and diabetic patients. Of note, the proportion of patients presenting with chest pain within 6 h of symptom onset, and with ST-segment elevation, was lower in each successive age group. Thirty-day mortality rates were higher in older age groups (65 to 69: 10.9%, 70 to 74: 14.1%, 75 to 79: 18.5%, 80 to 84: 23.2%, ≥85: 31.2%, $p = 0.001$ for trend). The effect of age persisted but was attenuated after adjustment for differences in patient characteristics; similar trends were observed for one-year mortality.

CONCLUSIONS Our data indicate significant age-associated differences in clinical characteristics in elderly patients with AMI, which account for some of the age-associated differences in mortality. The practice of grouping older patients together as a single age group may obscure important age-associated differences. (J Am Coll Cardiol 2001;38:736–41) © 2001 by the American College of Cardiology

Elderly patients, those 65 years of age and older, represent 13% of the U.S. population yet account for half of hospital admissions for acute myocardial infarction (AMI) and 80% of AMI deaths (1). Despite the greater risk of AMI among older patients and the increasing size of this population (1), the relationship between age, clinical presentation and outcome of AMI in elderly patients is incompletely understood. Many prior observational studies and clinical trials have classified elderly patients as a single population, not specifically evaluating differences in older subgroups, particularly those 75 years of age and older (2–13). The few studies that have explored age-associated differences in AMI presentation and outcomes in this cohort have been limited to small numbers of very elderly patients, usually drawn from individual centers or regions (3,5,7).

Accordingly, we sought to determine how clinical characteristics and outcomes of elderly patients hospitalized with AMI vary by age. Using data from the Cooperative Cardiovascular Project (CCP), a cohort of Medicare beneficiaries hospitalized with AMI, we evaluated variations in clinical characteristics of elderly patients by age, the relationship of age, 30-day and one-year outcomes and the extent to which increased mortality was explained by age-associated variations in clinical characteristics. We anticipated that, rather than representing a homogeneous population, patients 65 years of age and older would exhibit significant differences in clinical characteristics by age and that higher mortality rates would be explained, in part, by differences in patients' clinical characteristics and treatment.

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METHODS

Study sample. The CCP sampling strategy has been explained previously (14). We evaluated patients age 65 years and older hospitalized with a confirmed AMI (15). Patients less than 65 years of age (n = 17,593), those without a confirmed AMI (n = 31,186), readmissions for AMI (n = 23,773) and patients transferred from another acute care hospital (n = 36,297) were excluded. In total, 71,629 (30.5%) hospitalizations met one or more of the exclusion criteria; the remaining 163,140 patients constitute the study sample.

Age stratification and patient characteristics. We categorized patients into five groups based on their age (years): 65 to 69, 70 to 74, 75 to 79, 80 to 84 and 85 and older. Most demographic and clinical characteristics were abstracted as categorical variables in the CCP database. Missing categorical data elements were assumed to be negative for the

Abbreviations and Acronyms

AMI	=	acute myocardial infarction
CABG	=	coronary artery bypass graft
CCP	=	Cooperative Cardiovascular Project
PTCA	=	percutaneous transluminal coronary angioplasty

variable. Missing values for continuous variables were imputed by the median value of the variable, and a separate indicator was used if the percentage of missing values (serum albumin, left ventricular ejection fraction) was more than 5%. Continuous variables were then dichotomized or categorized based on clinical significance. A history of AMI, percutaneous transluminal coronary angioplasty (PTCA), coronary artery bypass grafting (CABG) or congestive heart failure was considered to be evidence of prior coronary artery disease. Renal insufficiency was defined as blood urea nitrogen level >50 mg/dl, or creatinine >2.0 mg/dl on admission (for renal insufficiency as a comorbidity) or highest creatinine >2.0 mg/dl during the hospital stay (for renal insufficiency as a complication). Functional status was considered to be impaired if the patient was unable to ambulate without assistance, was incontinent, or if dementia was present. Heart failure was present on admission if documented by a physician or on the admission chest radiograph interpretation. Patients were also evaluated for use of AMI therapies.

Hospital characteristics, physician characteristics and outcomes. Hospitals were characterized by linking records with the 1994 American Hospital Association Survey (16). The specialty of the attending physician was determined by linking records to a database of physician-reported specialties obtained from the Health Care Financing Administration (17,18). Patient mortality was determined by linking records with the Medicare Enrollment Database (19).

Statistical methods. We first examined the association of patient characteristics and older age by chi-square tests and analyses of variance, testing for both global differences and trends by age. Crude patient outcomes were compared across age strata using bivariate analysis, and the independent association of age with 30-day and one-year mortality was evaluated sequentially by multivariable logistic regression analyses adjusted for patient and hospital characteristics, physician specialty, medical therapy use and clustering of patients by hospital. SAS 6.12 software (SAS Institute Inc., Cary, North Carolina) and STATA 6.0 software (Stata Corporation, College Station, Texas) were used for analysis.

RESULTS

Patient characteristics. Older elderly patients hospitalized with AMI were different than younger elderly patients. The proportion of women in the oldest age group was almost double that in the younger group, while nonwhite patients were represented in smaller numbers. Diabetes, smoking, chronic lung disease and a history of prior revascularization were less frequently encountered in older patients. In contrast, a history of heart failure, stroke, renal insufficiency and laboratory evidence of comorbid conditions (low hematocrit, low serum sodium, low albumin) were considerably higher in the older age groups. The proportion of patients with limited functional status was higher in older age groups, affecting almost half of patients age ≥85 years. Older elderly patients presented less frequently with chest pain, ST-segment elevation, left bundle branch block, within 6 h of symptom onset, and had smaller enzymatic evidence of ischemia (lower creatine kinase) than younger elderly patients. In contrast, heart failure, tachycardia and anterior location of infarct were more common in older individuals (Table 1).

Characteristics of in-hospital care. Older patients were more likely to be admitted to a facility without revascularization capabilities, less likely to be cared for by a cardiologist, undergo stress testing, left ventricular ejection fraction assessment or invasive cardiovascular procedures during hospitalization compared with younger patients. Crude rates of aspirin, reperfusion therapy (thrombolytic or primary PTCA) and beta-adrenergic blocking agent use were also lower in older elderly patients (Table 2).

Complications and mortality. Cardiovascular complications, including hypotension, shock, atrial fibrillation, heart failure and stroke and noncardiovascular complications, including pneumonia and renal insufficiency on admission, were more common in older patients. Older patients were more likely to be discharged to a nonacute care facility and less likely to be transferred to another acute-care facility than younger elderly patients (Table 2).

Thirty-day and one-year mortality rates were markedly higher for older elderly patients compared with younger elderly patients, with a trend of successively higher mortality in intermediate age groups (Fig. 1). Age-associated mortality risks were attenuated but persisted after adjustment for patient, hospital and physician characteristics and AMI care. Most of the attenuation was accounted for by patient clinical characteristics and AMI care (Table 3).

DISCUSSION

This study provides a comprehensive national perspective on the association of patient characteristics and outcomes by age among a large representative sample of elderly patients with AMI. We observed marked differences by age among patients 65 years of age and older. This finding suggests that the practice of grouping older patients together in a single group of patients 65 years of age and older may provide a perspective that is not representative of all patients in this group. While statistically convenient when studies have small numbers of older patients, the clinical relevance of this approach is questionable.

Previous research has found that older age is associated with a higher prevalence of comorbid conditions, atypical AMI presentation, nondiagnostic electrocardiograms, com-

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Table 1. Patient Characteristics by Patient Age Group (%)

Characteristics	Age Groups (yrs)				
	65–69	70–74	75–79	80–84	85+
n (%)	33,259 (20.6)	38,212 (23.7)	34,595 (21.4)	29,593 (18.3)	25,681 (15.9)
Female gender	37.5	42.7	48.7	55.8	65.0
Nonwhite race	12.2	10.5	9.1	8.4	8.0
Functional status (%)					
Any functional impairment	11.3	15.3	23.0	32.1	48.0
Immobility	8.6	11.5	17.3	24.3	38.2
Incontinence	3.4	4.5	6.6	9.1	15.8
Dementia	1.2	2.4	5.4	9.1	14.8
Admission from chronic care/SNF	1.6	2.5	4.4	7.5	16.8
CAD history (%)					
Any CAD history	41.6	44.6	47.1	48.6	51.4
Prior AMI*	28.2	29.4	29.5	29.6	28.5
Prior CABG	15.1	15.6	14.0	10.2	4.4
Prior PTCA	9.1	8.4	6.8	4.8	2.3
Prior CHF	13.0	16.2	20.7	26.3	34.6
Prior stroke	10.3	12.5	15.2	16.4	16.6
Medical history (%)					
Hypertension	59.6	61.8	63.2	63.5	60.3
Diabetes	32.8	33.6	32.9	29.3	21.8
Terminal illness	1.6	2.0	2.4	2.3	2.4
Current smoker	27.4	18.9	12.3	7.8	3.5
COPD	20.9	21.5	21.7	19.9	16.3
Renal failure	6.6	8.5	10.5	12.8	15.9
Clinical presentation (%)					
Angina at presentation	89.2	87.0	84.4	81.2	73.9
Angina <6 h	58.4	56.1	53.4	49.7	43.4
Hypertension	31.8	32.3	31.8	31.2	27.6
Heart rate >100 beats/min	21.5	23.7	26.4	28.0	30.2
Heart failure	25.1	29.3	35.1	40.9	48.0
LVEF (unknown, <25, 25–40, >40)†	32/5/14/49	33/6/15/47	34/6/16/44	39/6/16/39	47/6/15/32
Cardiomegaly	27.7	31.7	36.7	41.7	46.6
ECG characteristics (%)					
Eligible for acute reperfusion‡	31.5	30.0	27.7	25.7	22.3
ST-segment elevation	31.9	30.6	28.7	27.5	26.0
Left bundle branch block	4.1	5.3	6.7	7.9	9.5
Right bundle branch block	5.6	6.6	8.1	8.7	10.0
Atrial fibrillation	5.5	7.2	9.9	11.6	14.5
Ventricular tachycardia*	0.8	0.7	0.8	0.9	0.8
2nd/3rd degree heart block	1.2	1.3	1.4	1.4	1.6
Fascicular block	5.2	6.1	7.2	8.0	9.3
Paced rhythm	0.7	1.2	1.7	2.3	2.7
AMI location (%)					
Anterior/septal AMI	43.9	45.1	46.7	48.2	49.6
Inferior/posterior AMI	54.0	51.5	48.3	44.8	40.2
Laboratory values (%)					
Highest CK 5 times normal	33.4	32.6	30.0	27.8	26.6
Hematocrit <30%	3.2	3.8	4.5	5.7	6.9
Serum sodium <130 meq/liter	1.9	2.2	2.5	3.0	3.7
Serum albumin <3 g/dl	3.4	3.8	4.4	4.8	5.7
Cardiac care facilities (%)†					
CABG capable/catheterization capable/no invasive facilities	40/22/38	39/22/38	37/23/40	35/23/43	34/23/44
Physician specialty (%)†					
Cardiologist/internist/family or general practice/other	37/31/16/18	35/34/17/17	32/36/18/16	28/38/20/15	23/42/23/14

*p = 0.001 for test of trend unless otherwise noted; †may not equal 100 due to rounding; ‡ST-segment elevation or left bundle branch block and presentation within 6 h of symptom onset.

AMI = acute myocardial infarction; CABG = coronary artery bypass graft surgery; CAD = coronary artery disease; CHF = congestive heart failure; CK = creatine kinase; COPD = chronic obstructive pulmonary disease; ECG = electrocardiographic; LVEF = left ventricular ejection fraction; PTCA = percutaneous transluminal coronary angioplasty; SNF = skilled nursing facility.

Table 2. Myocardial Infarction Therapy Use, In-Hospital Course and Complications by Patient Age Group

	Age Groups (yrs)				
Characteristics	65–69	70–74	75–79	80–84	85+
Medical therapy (%)					
Reperfusion therapy	12.3	10.0	7.4	4.6	2.1
Aspirin during hospitalization	83.9	80.8	77.0	74.5	69.2
Beta-blockers during hospitalization	52.3	49.0	44.9	40.5	32.9
Coronary procedures (%)					
Cardiac catheterization	65.2	58.4	46.6	28.6	9.7
Revascularization among those with catheterization	44.1	38.7	29.8	17.1	5.5
PTCA	28.3	23.8	18.0	11.4	4.3
CABG	20.0	18.4	14.3	7.0	1.5
Echocardiogram	54.1	56.1	58.6	59.0	54.7
MUGA	3.3	3.5	3.5	3.1	2.1
Stress test	14.5	13.4	12.1	9.8	4.4
Complications during hospitalization (%)					
Hypotension*	23.3	23.6	24.3	24.4	25.6
Shock	6.5	7.3	8.1	8.4	8.9
Atrial fibrillation/flutter	12.9	16.4	21.3	24.2	28.8
CHF/pulmonary edema	36.2	41.4	49.1	56.5	64.6
Stroke	2.1	2.5	3.1	3.2	3.7
Renal insufficiency	10.7	13.5	16.5	19.7	22.8
Bleeding or hemorrhage	15.9	16.7	17.3	16.8	15.4
Transfusion given	11.6	13.0	13.0	11.6	9.6
Pneumonia	6.7	8.1	9.5	11.0	14.1
Discharge status-home/transfer/SNF/other†	64/31/5/0	65/28/7/0	66/24/10/0	67/16/17/0	61/6/33/0
Length of stay >10 days‡	18.4	21.0	24.8	27.1	28.6

*p = 0.001 for test of trend unless otherwise noted; †may not equal 100 due to rounding; ‡length of stay figure excludes patients who died during hospitalization, were transferred out or underwent CABG during hospitalization.

CABG = coronary artery bypass graft surgery; CHF = congestive heart failure; MUGA = multiple gated acquisition; PTCA = percutaneous transluminal coronary angioplasty; SNF = skilled nursing facility.

plications and mortality (2–7,10–13,20–22). However, these studies have typically enrolled small numbers of patients, often from clinical trials and, thus, reflect the experience of selected patient populations (2,6,12,13). The clinical detail contained in the CCP allowed us to evaluate characteristics of elderly AMI patients with an unprecedented level of detail in a cohort drawn from a nationally representative population. Though some of our findings are not surprising, CCP provides an opportunity to quantify the association of age and patients' characteristics in an older group of patients.

Age-associated variation in AMI characteristics. Comorbidity varied by age, with some comorbid conditions less prevalent in older elderly patients and others more prevalent. A lower prevalence of certain comorbid conditions in older patients, such as diabetes or chronic lung disease, may reflect a survivor effect with earlier mortality among those with disease, leaving fewer patients with disease surviving to older age. The lower prevalence of prior CABG or PTCA in older subjects may indicate a survivor effect, but it may alternatively represent historical practice patterns of fewer coronary interventions when these patients were younger and the current practice of limited procedure use in older patients.

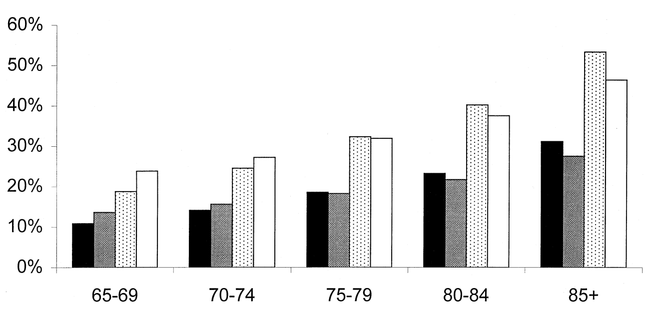

Figure 1. Crude 30-day and one-year mortality among different age groups of elderly patients with acute myocardial infarction. **Solid bar** = 30-day unadjusted; **spotted bar** = one-year unadjusted; **hatched bar** = 30-day adjusted; **open bar** = one-year adjusted.

We observed significant variations in the clinical presentation of AMI in elderly patients. Older elderly AMI patients often presented without ST-segment elevation or with electrocardiographic presentations that were difficult to interpret, such as paced rhythms and left bundle branch block. The combination of atypical symptoms, delayed presentation and nondiagnostic electrocardiographic presentation indicates the difficulty in using traditional cues to facilitate early triage and diagnosis. This observation may account for the lower rates of therapy use in older elderly patients. Variations in therapy use are likely further exacerbated by older elderly patients' treatment at smaller hospitals and management by nonspecialists (17,18,23–25).

Age-associated variation in AMI mortality. A large portion of age-associated variation in mortality was attributable to age-related variation in patients' clinical characteristics and AMI care, as adjustment for these factors resulted in the

Table 3. Odds of Short- and Long-Term Mortality Among Patient Age Groups

Mortality	ROC	Age Groups (yrs) 65–69	70–74	75–79	80–84	85+
30-day						
Unadjusted	0.62	Referent	1.35 (1.29, 1.41)	1.87 (1.78, 1.95)	2.48 (2.38, 2.69)	3.71 (3.55, 3.88)
Adjusted for patient race and gender	0.63	Referent	1.34 (1.28, 1.40)	1.85 (1.77, 1.93)	2.45 (2.34, 2.56)	3.63 (3.48, 3.80)
Adjusted for patient race, gender and clinical characteristics factors	0.78	Referent	1.26 (1.20, 1.32)	1.62 (1.54, 1.69)	1.95 (1.86, 2.05)	2.44 (2.32, 2.56)
Adjusted for patient race, gender, clinical characteristics, physician specialty, hospital factors	0.78	Referent	1.26 (1.20, 1.32)	1.62 (1.54, 1.70)	1.96 (1.86, 2.05)	2.44 (2.32, 2.57)
Adjusted for patient race, gender, clinical characteristics, physician specialty, hospital factors, AMI therapies	0.81	Referent	1.21 (1.16, 1.27)	1.49 (1.42, 1.56)	1.69 (1.61, 1.78)	2.00 (1.90, 2.11)
One-year						
Unadjusted	0.65	Referent	1.40 (1.35, 1.45)	2.06 (1.99, 2.14)	2.91 (2.80, 3.02)	4.94 (4.76, 5.13)
Adjusted for patient race and gender	0.65	Referent	1.40 (1.36, 1.46)	2.06 (1.99, 2.14)	2.91 (2.81, 3.02)	4.94 (4.76, 5.13)
Adjusted for patient race, gender and clinical characteristics	0.79	Referent	1.30 (1.26, 1.36)	1.75 (1.69, 1.82)	2.24 (2.15, 2.33)	3.16 (3.03, 3.30)
Adjusted for patient race, gender, clinical characteristics, physician specialty, hospital factors	0.79	Referent	1.30 (1.25, 1.35)	1.75 (1.68, 1.82)	2.23 (2.14, 2.32)	3.15 (3.02, 3.29)
Adjusted for patient race, gender, clinical characteristics, physician specialty, hospital factors, AMI therapies	0.81	Referent	1.27 (1.22, 1.32)	1.64 (1.57, 1.70)	1.96 (1.88, 2.04)	2.61 (2.49, 2.73)

Data are presented as odds ratios with 95% confidence intervals for odds of mortality at 30 days and 1 yr after infarction among elderly patients (aged ≥70 yrs) compared with patients aged 65–69 yrs.
AMI = acute myocardial infarction; ROC = receiver operator characteristic.

greatest reduction in the age-associated odds of 30-day and one-year mortality. Interestingly, adjustments for specialty of the attending physician and hospital characteristics had only a minor effect on age-associated variations in mortality, suggesting that, while these factors may influence process of care, they have a limited direct contribution to patient outcomes among elderly patients. Nevertheless, even after such adjustments, age remained an important predictor of 30-day and one-year mortality, with a relationship that appeared linear.

The independent association of age with mortality likely reflected the influence of many factors. Older age is associated with significant cardiovascular structural and physiologic changes that might predispose patients to adverse outcomes, including abnormalities of left ventricular diastolic function (26,27), decrease in systemic vascular compliance (28), increase in left ventricular mass index (29) and altered neurohormonal and autonomic influences (30,31). Similarly, coagulation factors (VII, VIII and IX) are increased compared with anticoagulation factors (antithrombin III, Protein C and Protein S) with advancing age, leading to a greater risk of thrombosis in older patients (32). Whether adjustment for these and other important factors (such as the severity of coronary artery disease) associated with age and outcomes not accounted for in this study would lead to further attenuation of the association between age and mortality is unknown.

Study limitations. The design of the CCP precludes comparisons with representative patients younger than 65 years of age. Our aim, however, was to illuminate differences in characteristics among patients 65 years of age and older since this group is commonly defined as a single group. Additionally, while CCP was a national cohort, it did not include patients enrolled in managed care. The exclusion of managed care patients may have resulted in a healthier cohort due to the increased enrollment of sicker patients in health maintenance organizations (for purposes of obtaining pharmaceutical benefits or other coverage) or a sicker cohort due to the enrollment of healthier patients by risk-averse health maintenance organizations. This issue is unlikely to have substantially affected our main findings.

Conclusions. Patients 65 years of age and older with AMI are a heterogeneous group by age. Studies that classify elderly patients as a single population may overlook important differences in elderly patients, particularly the oldest, who are often excluded from clinical research studies.

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