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Sex Differences in Acute Myocardial Infarction Hospital Management and Outcomes

Update From Facilities With Comparable Standards of Quality Care

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Background: Acute myocardial infarction (AMI) sex disparities in management and outcomes have long been attributed to multiple factors, although questions regarding their relevance have not been fully addressed. **Objective:** The aim of this study was to identify current factors associated with sex-related AMI management and outcomes disparities in hospitals with comparable quality care standards. **Methods:** This is a cross-sectional study of 299 women and 540 men with AMI discharged in 2013 from 3 southern California hospitals with tertiary cardiac care. Outcomes (adjusted by demographic/clinical variables using multiple logistic regression) included mortality (in-hospital, 30 days), 30-day readmissions, invasive/revascularization procedures, and quality medication performance measures (aspirin, statins/antilipids, β-blockers, angiotensin-converting enzyme inhibitors, <90-minute door-balloon time). **Results:** Performance was similar to the top 10% National Inpatient Quality AMI Measures. Women had similar mortality, 30-day readmission rates, and performance on medication quality measures compared with men; readmissions were higher in patients with County Services/Medicaid or no medical insurance regardless of sex. Women had similar cardiac catheterization and ST-segment elevation myocardial infarction percutaneous coronary intervention rates but significantly less percutaneous coronary intervention for non–ST-segment elevation myocardial infarction (39.1% vs 52.1%, $P = .008$) and coronary artery bypass graft (6.7% vs 14.1%, $P < .001$) than men. **Conclusions:** Women with AMI had similar early mortality, 30-day readmissions and quality performance measures compared with men across hospitals with current quality care standards. Type of medical insurance influenced readmission rates for both sexes. Sex disparities in coronary revascularization procedures were likely determined by differences in AMI type and coronary disease vascular expression.

KEY WORDS: acute myocardial infarction, coronary revascularization, disparities, women

Progressive declines in cardiovascular disease death rates have been consistently reported worldwide and in the United States during the past 3 decades, although mortality has decreased substantially less for women.[1–4] A similar sex disparity has been reported in the United States for the decline in coronary heart disease mortality including significant reversals of this trend for the period between 1997 and 2002 in a subgroup of younger women (age, 35–44 years).[5] Moreover, the prognosis for women after an acute myocardial infarction (AMI) compared with men has been the subject of contrasting reports and nuanced opinions.[5–9] Although AMI mortality in women is gradually declining, the disproportionate toll that has occurred in younger female groups without a clear explanation[5] is of great concern. Results from

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multiple studies have shown that women are less likely to receive currently accepted drug therapies (aspirin [ASA] and β-blockers on admission, statins at discharge) as well as less cardiac catheterization (cath), thrombolysis, percutaneous coronary intervention (PCI) procedures, and coronary artery bypass graft (CABG) surgery after AMI compared with men.[10–17] Although newer studies have suggested improvements in these sex-related disparities,[9,18–20] it is uncertain to what extent differences still persist and what are the determining factors. Age, comorbidities, socioeconomic status, race/ethnicity, modality of clinical presentation, facility's quality of care, provider-related behavior, and biological/coronary vascular features have been suggested as factors, but questions regarding their relevance in current US clinical practice have not been fully addressed.

The purpose of this study was to analyze the relationship of select factors with the outcomes and management of men and women who were discharged alive in 2013 with the primary diagnosis of AMI from 3 hospital facilities with similar current standards of quality cardiac care, serving a demographically diverse southern California population (San Diego County region). The study was designed to minimize the influence of unequal healthcare resources, an issue that has confounded results from previous large national studies, as well as explore quality of care in a population with diverse racial/ethnic and socioeconomic characteristics. This information may assist with the formulation of healthcare policies and practices that reduce care disparities and maximize the quality of care delivered by cardiovascular nurses. Relationships of the race/ethnicity characteristics of this group with quality of care and outcomes were analyzed in a recent publication.[21]

Methods

A cross-sectional data analysis was carried out using a common electronic medical record data warehouse of 839 adult patients (540 men and 299 women) admitted and discharged alive in calendar year 2013 with a primary diagnosis of AMI from 3 general nonprofit, nonteaching hospitals in San Diego County with on-site 24/7 cath, PCI, and CABG services. There were no significant differences between the 3 hospitals in the proportion of men and women included in the study. Diagnosis of AMI was established according to *International Classification of Diseases, Ninth Revision*, codes (410.00–410.91) for electrocardiographic features and the standard diagnostic changes of biomarkers (CK-MB and troponin I).[22]

Race/ethnicity and language preference were self-reported by the patient or companion at the time of admission. The racial/ethnic representation in this study roughly reflected demographic proportions in San Diego County where 75% to 80% are categorized as non-Hispanic white or Hispanic. Asians, non-Hispanic blacks, and "others" (including Native Americans, Hawaiian/Pacific Islander, miscellaneous) corresponded to 20% to 25% of the population. Medical insurance was considered as a proxy of socioeconomic status[23] and classified in 5 categories: (1) no insurance/self-pay, (2) county programs, (3) Medi-Cal/Medicaid with or without Medicare, (4) Medicare/supplemental commercial, or (5) commercial (HMO, Tricare, PPO, and workers' compensation/other) without Medicare. Select outcomes and performance measures were analyzed in 2 dichotomous insurance groups: group 1 ("commercial-private" insurance composed by categories 4 and 5) versus group 2 ("no insurance–County Services–Medi-Cal/Medicaid" including categories 1–3).

The patients included in the study met criteria used by the Specifications Manual for National Hospital Inpatient Quality Measures Discharges 01-01-13 (1Q13) through 12-31-13 (4Q13) AMI, version 4.2.[24] Moreover, study analyses compared the demographic groups that were included versus excluded based on the measure specifications. In addition to demographic information, data elements included specific comorbid health conditions and calculation of the Charlson Comorbidity Index.

In-hospital mortality, 30-day mortality, and 30-day readmission rates were the primary outcomes. Quality medication/performance measures included ASA at admission and discharge, β-blocker at discharge, angiotensin-converting enzyme inhibitor or angiotensin receptor blocker for left ventricular systolic dysfunction, statins/antilipids at discharge, and less than 90-minute door-to-balloon for ST-segment elevation myocardial infarction (STEMI) only and were used as predictors in a multiple logistic regression model. Secondary outcomes were the use of PCI, cath, and/or CABG procedures during the index hospitalization. The study was reviewed and approved by the health system's institutional review board.

Statistical Analysis

Analysis of variance was used for between-group comparisons of quantitative outcomes; and the χ^2 test, when examining the relationship between 2 categorical variables. For 2×2 contingency tables, odds ratios and 95% confidence intervals were calculated in addition to the test statistics. Differences in independent proportions and between-group differences of more than 2 groups were analyzed using the Z test. Effect sizes were reported to complement significance testing. The level of significance was set at $\alpha = .05$ for all analyses.[25] A sequential approach to multiple logistic regression was performed, with the first step of entry including the individual predictors (ie, age and sex) and the second step including the multiplicative term (ie, interaction of age and sex). Finally, a multiple logistic regression of primary (in-hospital and 30-day mortality, 30-day

readmission) and secondary (PCI, CABG, cath) outcomes was performed that adjusted for the following covariates: age, sex, race/ethnicity, commercial-private insurance, current smoking, STEMI, Charlson Comorbidity Index score, comorbidities (hypertension, diabetes, dyslipidemia, chronic renal disease, cerebrovascular disease), history of PCI, and history of CABG to test for sex-related differences.

Results

Baseline Characteristics

The study included 839 adult patients (540 men and 299 women). There were no statistically significant differences based on sex for race/ethnicity representation, use of English as the preferred language, medical insurance characteristics, or proportion of obesity (body mass index > 30 kg/m^2). However, women were significantly older, more likely to be hypertensive and dyslipidemic and have diabetes, had higher Charlson Comorbidity Index scores, and were less likely to be current smokers than men (14.5% vs 30%, $P < .001$) (Table 1 and Supplemental Table 1, http://links.lww.com/JCN/A61). More than two-thirds of women (67.6%) were diagnosed with a non-STEMI (NSTEMI), compared with 53.9% in men (Table 2).

TABLE 1 Relationship of Sex With Demographics and Patient Characteristics for Patients With Acute Myocardial Infarction Discharge Diagnosis in 2013

	Sex		
Characteristic	Male (n = 540, 64.4%)	Female (n = 299, 35.6%)	*P*
Age, mean (SD), y	63.37 (13.80)	71.93 (14.26)	<.001
Range (minimum to maximum)	20–96	30–103	
Race/ethnicity			.911
Non-Hispanic white	247 (45.7%)	149 (49.8%)	
Hispanic	116 (21.5%)	61 (20.4%)	
Non-Hispanic black	21 (3.9%)	15 (5.0%)	
Asian	46 (8.5%)	23 (7.7%)	
Other	90 (16.7%)	47 (15.7%)	
Unknown	20 (3.7%)	4 (1.3%)	
English as the preferred language	435 (80.6%)	242 (80.9%)	.894
Insurance			<.001
No insurance, self-pay	32 (5.9%)	13 (4.3%)	
County programs	55 (10.2%)	14 (4.7%)	
Medi-Cal, Medicaid	214 (39.6%)	151 (50.5%)	
Medicare, Supplemental	68 (12.6%)	57 (19.1%)	
Commercial	171 (31.7%)	64 (21.4%)	
% with commercial or private insurance	239 (44.3%)	121 (40.5%)	.288
BMI ≥ 30, kg/m^2	160 (33.3%)	89 (33.5%)	.957
Smoking status			<.001
Current	154 (30.0%)	41 (14.5%)	
Former	135 (26.3%)	63 (22.3%)	
Nonsmoker	225 (43.8%)	179 (63.3%)	
% current smoker (vs nonsmoker)	154 (30.0%)	41 (14.5%)	<.001

Abbreviation: BMI, body mass index.

Rates of Mortality, Readmission, and Length of Stay

There were no significant differences in in-hospital mortality, 30-day mortality, or 30-day readmission rates according to sex after multivariable logistic regression data adjustment (Table 2). In addition, there were no statistically significant differences for rates of in-hospital or 30-day mortality based on the type of AMI classification (STEMI or NSTEMI). Patients with NSTEMI had a significantly higher 30-day readmission rate than those with STEMI (Table 3). Although women were older than men and had higher Charlson Comorbidity Index scores, there were no significant differences in average length of stay (Table 2).

Cardiac Catheterization and Coronary Revascularization Procedures

Men had higher unadjusted rates of cath, CABG, and PCI than women, but after full data adjustments as described previously, statistically significantly higher proportions of CABG persisted for men, but not for sex differences in PCI or cath (Table 2). A subsequent comparison of PCI rates by sex and AMI classification indicated that men were significantly more likely than women to receive PCI for NSTEMI (52.1% vs 39.1%, $P = .008$) but not for STEMI (82.3% vs 80.4%, $P = .683$) (Table 3).

Quality Performance Measures

There were no statistically significant sex-related differences in medication use quality measures, including ASA on admission or at discharge, β-blockers, statin/antilipids, or angiotensin-converting enzyme inhibitor/angiotensin receptor blocker for left ventricular systolic dysfunction at discharge (Supplemental Table 2, http://links.lww.com/JCN/A62). The performance according to the National Hospital Inpatient Quality Measures Discharges for each specified measure was 100%, with the exception of compliance with door-to-balloon time of less than 90 minutes (96.2% in women, 98.6% in men). After multivariable logistic regression data adjustment, there were no significant differences between the proportion of men and women (57.4% vs 52.6%, $P = .416$) with STEMI who met the less than 90-minute door-to-balloon time standard (Table 2). Comparison of the study facilities with the top 10% benchmark for All Hospitals—2013 National Inpatient Quality AMI Measures showed similar performance marks for all measures.

TABLE 2 Relationship of Sex With Clinical Outcomes and Performance Measures for Patients With Acute Myocardial Infarction Discharge Diagnosis in 2013

Characteristic	Sex, n (%)		
	Male (N = 540)	Female (N = 299)	*P*
History of procedures			
Percutaneous coronary intervention	31 (5.7%)	12 (4.0%)	.277
Coronary artery bypass graft	4 (0.7%)	4 (1.3%)	.394
Length of stay, mean (SD)	5.13 (7.36)	4.99 (5.27)	.766
Clinical outcomes[a]			
ST-segment elevation myocardial infarction (STEMI)	249 (46.1%)	97 (32.4%)	<.001
Mortality in hospital	25 (4.6%)	14 (4.7%)	.854
Mortality at 30 d	29 (5.4%)	17 (5.7%)	.797
Readmission at 30 d	51 (9.4%)	45 (15.1%)	.124
Performance measures[b]			
Percutaneous coronary intervention	354 (65.6%)	157 (52.5%)	.422
Door-to-balloon time ≤ 90 min (STEMI only)	143 (57.4%)	51 (52.6%)	.416
Coronary artery bypass graft	76 (14.1%)	20 (6.7%)	.001
Cardiac catheterization	465 (86.1%)	218 (72.9%)	.253

[a]The relationship of sex to clinical outcome measure analyses was based on a fully adjusted logistical regression model that accounted for demographics, acute myocardial infarction classification, comorbidities, history of coronary revascularization, and facility.

[b]The relationship of sex to performance measure analyses was based on a fully adjusted logistical regression model that accounted for age, race/ethnicity, acute myocardial infarction classification, comorbidities, history of coronary revascularization, and facility.

Medical Insurance, Demographics, and Outcomes

There were no statistically significant differences in the proportion of patients with commercial-private medical insurance according to sex (Table 1). The readmission rate was significantly higher in patients with a group 2 type of insurance (no insurance–County Services–Medi-Cal/Medicaid), but no significant differences were noted in mortality or revascularization procedures according to the type of insurance (Table 4).

Discussion

Results from this study, carried out in 3 hospitals with similar contemporary quality standards of AMI care in the United States, suggest that sex differences in AMI management were not related to unequal use of current standard management guidelines but to selective revascularization procedures likely driven by clinical decisions based on the modality of AMI clinical presentation and/or coronary artery disease vascular characteristics.

Acute Myocardial Infarction Early Mortality and Readmissions According to Sex

The similar short-term mortality rates (in-hospital and 30-day) for women and men after AMI observed in this study are consistent with trends noted in some studies in the last 10 years,[3,4,8,9] but at variance with others.[1,26,27] A study by Jneid et al[16] found no significant sex differences for overall in-hospital mortality but higher mortality in women presenting with STEMI, attributed to underuse or delayed use of reperfusion and revascularization procedures. A similar conclusion was reached in a study by Milcent et al,[27] who found that age-adjusted hospital mortality after AMI was higher in women and thought to be related to lower use of PCI. Bangalore et al[26] found higher mortality and a greater delay in PCI in younger women (<45 years old) presenting with STEMI than in younger men. In contrast with these studies, there were no statistically significant sex differences associated with in-hospital or 30-day mortality in fully adjusted data that included age and AMI presentation. In addition, no significant differences in rates of mortality (in-hospital or 30-day) for STEMI and NSTEMI in fully adjusted data, nor a larger delay (door-to-balloon time) in receiving STEMI PCI procedures for women, were documented. Although women were older and had a higher Charlson Comorbidity Index score than men, results showed not only similar early mortality but also no significant differences in length of stay and 30-day readmissions. It is conceivable that these outcomes reflect the benefits of a significantly lower rate of current smokers in women.

As discussed by the authors in a recent publication,[21] only medical insurance seemed to be a significant determinant of 30-day readmission rate regardless of sex, larger in patients with County Services, Medicaid/Medi-Cal, or no medical insurance (group 2). This finding may reflect differences in postdischarge management driven by lack of insurance or limitations in access to providers and/or the influence of other undetermined socioeconomic factors.

Influence of Race/Ethnicity in Acute Myocardial Infarction Outcomes

It is of note that the authors included a population with more racial/ethnic diversity (51.5% racial/ethnic minorities vs 48.5% non-Hispanic whites) than most US regions.[28] However, to the best of the authors' knowledge, there is no information published about the influence of sex-related race/ethnicity characteristics in AMI management disparities in a more diverse population. Although the patients' race/ethnicity in this study reflected the demographic regional predominance of non-Hispanic whites and Hispanics, all racial/ethnic groups were represented equally according to sex. Moreover, patients'

TABLE 3 Rate of Percutaneous Coronary Intervention Procedures and Clinical Outcomes by Sex and Acute Myocardial Infarction Classification for Patients With Acute Myocardial Infarction Discharge Diagnosis in 2013

	Male		Female	
	NSTEMI (n = 275)	STEMI (n = 223)	NSTEMI (n = 194)	STEMI (n = 86)
PCI procedure	52.1%[a]	82.3%	39.1%[a]	80.4%
Clinical outcomes				
Mortality in hospital	2.4%	3.7%	2.8%	7.7%
Mortality at 30 d	3.3%	4.5%	4.1%	8.2%
Readmission at 30 d	11.6%	7.2%	17.5%	11.6%
Results from *Z* tests for Independent Proportions				
[a]PCI procedures	Significant differences ($z = 2.65$, $p = .008$) by sex for NSTEMI but not for STEMI ($z = 0.408$, $p = .683$).			
Mortality in hospital	No significant differences by sex for NSTEMI ($z = 0.227$, $p = .821$) or STEMI ($z = 1.27$, $p = .205$).			
Mortality at 30 d	No significant differences by sex for NSTEMI ($z = 0.448$, $p = .654$) or STEMI ($z = 1.15$, $p = .251$).			
Readmission at 30 d	No significant differences by sex for NSTEMI ($z = 1.77$, $p = .077$) or STEMI ($z = 1.14$, $p = .255$).			

Table 3 analyses for procedures and clinical outcomes were limited to patients with complete documentation of AMI classification and all covariates in the fully adjusted logistic regression (male, 498; female, 280). Patients with NSTEMI had a significantly higher 30-day readmission rate than those with STEMI (14.1% vs 8.4%; $z = 2.51$, $p = .012$).

Abbreviations: NSTEMI, non–ST-segment elevation myocardial infarction (prevalence rates based on the total sample: male, 53.9%; female, 67.6%); PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction (prevalence rates based on the total sample: male, 46.1%; female, 32.4%).

race/ethnicity was included in all multivariable logistic regression data analyses comparing outcomes. These results are in agreement with recently published data reporting similar AMI sex-related mortality after full adjustment for age, demographic characteristics, and comorbidities, in contrast to unadjusted observations from older studies.[3,4,8]

Influence of Preferred Language Use and Medical Insurance Type

Several studies have attributed disparities in the management of AMI in the United States to cultural/language characteristics and type of medical insurance, although targeted analyses in this study did not support sex-related differences in these factors.[29–31] It is noteworthy that these results compared favorably with performance metrics from the Specifications Manual for National Hospital Inpatient Quality Measures for AMI. Moreover, after multiple logistic regression adjustment for additional variables that included age, sex, medical insurance, cardiovascular risk factors, and comorbidities, results showed that sex was the only variable that was significantly associated with differences in interventional and surgical revascularization procedures.

Factors in Sex-Related Differences in Cardiac Catheterization and Coronary Revascularization Procedures

Although no significant differences were found for cath and PCI for STEMI, women received less NSTEMI PCI and CABG than men, a finding consistent with previous publications reporting lower rates of coronary revascularization procedures in women.[14–16,26] A study using microsimulation models estimated an absolute 3.4% higher rate of PCI in women if they had been treated as their male counterparts and related 0.45% of their higher early mortality to the difference in revascularization procedures.[28] Various interpretations of these differences, ranging from biological factors (women's vascular structural features, postmenopausal loss of the estrogen stimulating effect on circulating endothelial progenitor cells) to provider preferences, have been

TABLE 4 Relationship of Insurance Category With Clinical Outcomes and Performance Measures for Patients With Acute Myocardial Infarction Discharge Diagnosis in 2013

	Insurance Category		
Characteristic	Commercial-Private (n = 360)	No Insurance–County Services–Medicaid (n = 479)	*P*
Clinical outcomes			
Mortality in hospital	19 (5.3%)	20 (4.2%)	.454
Mortality at 30 d	20 (5.6%)	26 (5.4%)	.936
Readmission at 30 d	30 (8.3%)	66 (13.8%)	.015
Performance measures			
Percutaneous coronary intervention	231 (64.2%)	280 (58.5%)	.094
Coronary artery bypass graft	33 (9.2%)	63 (13.2%)	.074
Cardiac catheterization	302 (83.9%)	381 (79.5%)	.110

suggested.[32,33] The similar rates of STEMI PCI in men and women in this study contrast with the lower rate for NSTEMI PCI for women and suggest that sex-related differences in the coronary vascular atherosclerotic expression might be involved not only in this AMI PCI sex disparity but also in the differences in CABG procedures. Indeed, similar cath rates between men and women in this study suggest that the significant differences in revascularization procedures may have been determined by findings of different coronary vascular characteristics by the operators, although it is uncertain to what extent they may have been also driven by choices related to sex differences in comorbidities or patients' preferences. This discrepancy of women presenting similar rates of STEMI PCI but less CABG and NSTEMI PCI than men has not been specifically reported or commented in previous publications to the best of the authors' knowledge. The more readily identifiable culprit obstructive vessels in STEMI cases likely determined similar PCI rates in men and women in contrast to NSTEMI presentations, results that are consistent with less obstructive lesions in women as shown by the CRUSADE, American College of Cardiology-National Cardiovascular Data Registry, and GRACE multinational investigators,[34–36] thus providing a plausible explanation for a smaller proportion of PCI and CABG procedures in women. Significant differences in NSTEMI PCI and CABG procedures for women in this study were not associated with differences in in-hospital or 30-day mortality. However, it is uncertain whether they received those procedures in a similar proportion than men once readmitted or showed differences in mortality and readmissions after 30 days.

Limitations

This study has several limitations and strengths. It is uncertain whether these results are generalizable to a larger population or to US regions with a different racial and socioeconomic population mix. However, the location of the study was chosen to investigate hospitals with similar contemporary AMI quality of care, resources, and data collection processes yet serving a demographically diverse population to examine the potential influence of racial/ethnic and socioeconomic factors that may have confounded sex-related disparities of care until now. The focus on a "level playing field" in this study intended to offer a different view of quality of care in AMI because many of the documented disparities of care have been reported from data collected in hospitals with unequal quality of care and/or service resources or lacking a more current nationally representative patient diversity. No detailed analysis of the coronary angiography diagnostic findings was conducted because it was beyond the objectives of this study. However, it could have provided information to explain some of the sex disparities noticed in coronary revascularization. Smoking cessation counseling and referral to cardiac rehabilitation services, although routinely performed and available in the hospitals where the study was conducted, were not included as procedural variables because of lack of adequate documentation. Finally, medical insurance characteristics were used as a proxy of socioeconomic status because of incomplete information on patients' education and income.

What's New and Important

- Women and men presenting with AMI had similar access to pertinent pharmacotherapy, rates of cardiac cath, and PCI procedures for STEMI, refuting disparities in hospital service quality based on sex. Persistent sex differences in CABG and PCI for NSTEMI do not support quality-of-care disparities in women.
- Although men and women who presented with STEMI had similar rates of PCI, women received less CABG and NSTEMI PCI compared with men. These findings suggest sex-related differences in the coronary vascular characteristics involved in the infarction as contributors to revascularization disparities.
- There were similar rates of AMI early mortality for men and women in hospitals providing comparable quality care, but higher 30-day readmission rates for patients with County Services, Medicaid/Medi-Cal, or no medical insurance independent of sex suggest unresolved problems in access to outpatient care.

Conclusions

In women presenting with AMI to hospitals with comparable current quality of care, the only documented disparity was in the use of revascularization procedures, likely related to sex differences in the clinical presentation and/or coronary vascular characteristics. Unrestricted access to currently accepted standards of quality of care in AMI management in this study possibly reduced the influence of other factors attributed to inequalities of care by other researchers until now. However, the association of medical insurance characteristics with higher 30-day readmissions rates regardless of sex suggests possible factors related to outpatient access to care that warrant further research.

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