Gender Disparities in Percutaneous Coronary Interventions for Acute Myocardial Infarction in Pennsylvania

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Background: It has been shown that women are at greater risk than men of not receiving screening and treatment services for coronary heart disease. The purpose of this research was to determine whether there were gender disparities in the use of percutaneous coronary interventions (PCI) in the treatment of acute myocardial infarction (AMI) in Pennsylvania in 2000 and, if so, whether outcomes were affected.

Methods: Data included 10,170 patients treated with PCI and 21,181 patients medically managed in Pennsylvania hospitals. Multivariate analyses were performed using logistic regression to estimate the impact of gender on PCI. In addition, we performed retrospective matching on propensity scores to compare outcomes for women who were treated with PCI to comparable groups of women and men.

Results: After controlling for age, race/ethnicity, severity at admission, location of infarct, and source of admission, women had 24% lower odds than men of receiving PCI ($P < 0.0001$). In a propensity score-matched sample of 3023 women who received PCI and 3023 women who did not, women who received PCI were significantly less likely to die (2.3% vs. 10.4%, $P < 0.0001$). In a second propensity score-matched sample of 3329 women and 3329 similar men who received PCI, the difference in mortality was not statistically significant (1.59% vs. 1.92%, $P = 0.39$).

Conclusions: These results suggest that the morbidity and mortality associated with AMI in women could be reduced by increased use of PCI and that more women admitted for AMI should receive consideration for PCI.

Key Words: gender disparities, percutaneous coronary interventions, acute myocardial infarction, propensity scores

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Although coronary heart disease (CHD) is the leading cause of death in the United States for both men and women, research has shown that women experience greater morbidity and mortality from CHD[1,2] and are at greater risk than men of not receiving screening and treatment services for CHD.[3] It has been estimated that 38% of women compared with 25% of men will die within 1 year after an acute myocardial infarction (AMI).[1]

Numerous studies have investigated gender differences in treatment of AMI, including the frequency of cardiac catheterizations, coronary artery bypass graft (CABG) surgery, percutaneous coronary interventions (PCI), and the use of medications such as beta-blockers.[4–7] The predominant finding through the mid-1990s was that women were less likely to receive revascularization procedures and medications known to reduce morbidity and mortality.[3] There are several explanations for this phenomenon. For example, it is known that women experience a later onset of CHD than men and are therefore more likely to have a different risk factor profile and greater comorbidities than men.[8] Furthermore, the clinical presentation of AMI differs for women than for men, with women more likely to have normal coronary angiograms when presenting with chest pain.[8–12] Although a great deal of effort has been made to increase the awareness of the prevalence of CHD in women, there is still a perception that CHD is a "man's" disease. Thus, women may be screened and treated less aggressively than men and may be less likely to undergo either noninvasive or invasive cardiac diagnostic studies in an evaluation of their symptoms.[13,14] Finally, there are process of care issues that may in part explain the disparity because women and men access primary care differently. Women often rely on an obstetrician–gynecologist for all or part of their regular care. Screening and referral for coronary heart disease risk factors may be less of a priority for these physicians.[15]

Gender differences in treatment of patients presenting with an AMI are alarming because they may result in suboptimal outcomes for women. Reports from randomized clinical trials have consistently demonstrated survival benefits for patients with AMI with the use of reperfusion therapies that include either early fibrinolytic administration or percutaneous catheter-based interventions.[16–20] Recent studies comparing PCI to fibrinolytic therapy suggest more favorable outcomes in certain subsets of patients treated with the mechanical approach.[21–23] Although women presenting for PCI have a higher risk profile, acute and long-term clinical outcomes appear similar to men. In fact, the 2001 revised report of the American College of Cardiology/American Heart Association (ACC/AHA) Task Force on Practice Guidelines recommended that coronary intervention should be considered for women in need of revascularization with the anticipation of a favorable outcome.[24]

Although great strides are being made in an effort to narrow this difference in treatment between men and women with AMI, and in fact recent studies have shown equivalent use of cardiac catheterization and angioplasty in men and women, many questions remain.[4] For example, the resolution of the gender gap has not been uniform geographically, and understanding whether these differences in treatment ultimately affect outcomes has been hindered by selection bias in previous studies.[25–30] This study examines gender disparities in receipt of PCI for treatment of AMI in Pennsylvania and investigates the impact of gender differences in PCI use on patient outcomes after controlling for observable selection bias using a propensity score approach.

The specific research questions addressed are: (1) Is there a gender disparity in receipt of PCI after controlling for key covariates; (2) Is there a gender disparity in outcomes, controlling for access to PCI; (3) Does PCI affect outcomes in women; and (4) Is there a gender difference in outcomes for those receiving PCI?

METHODS

Patients

We studied patients treated for AMI in Pennsylvania during the year 2000. Data were provided by the Pennsylvania Health Care Cost Containment Council (PHC4), an independent state agency that collects data on inpatient and outpatient discharges from all acute care hospitals and freestanding surgical centers in Pennsylvania.[31] PHC4 also provides public reports on hospital and provider performance in Pennsylvania.[32,33] Previous studies have used PHC4 discharge data to study percutaneous coronary interventions.[34,35]

International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes were used to identify patients admitted for AMI. We included patients admitted to an acute care facility with an ICD-9-CM principal diagnosis of 410.X1 (acute myocardial infarction, initial episode of care) who were not discharged to another acute care facility and who did not leave against medical advice. Our final study sample included 31,351 patients: (1) 10,170 patients who received PCI as part of their treatment and were identified by a primary or secondary ICD-9-CM procedure code of 36.01 (single-vessel percutaneous transluminal coronary angioplasty [PTCA] or coronary atherectomy without mention of thrombolytic agent), 36.02 (single-vessel PTCA or coronary atherectomy with mention of thrombolytic agent), 36.05 (multiple-vessel PTCA or coronary atherectomy performed during the same operation, with or without mention of thrombolytic agent), 36.06 (insertion of nondrug-eluting coronary artery stent(s)) and (2) 21,181 patients whose treatment was defined as medical management. Note that the PCI treatment strategy may also include fibrinolytic therapy.

Variables

The data set contained demographic characteristics of patients (age, gender, race/ethnicity), ICD-9-CM diagnosis and procedure codes, the Admission Severity Group, source of admission, discharge destination, charges, hospital days, and discharge status. Race and ethnicity variables were coded by the admitting nurse and may not be consistent with self-reported race or ethnicity. The transfer variable is a binary variable derived from source of admission indicating whether the patient was transferred from another acute care facility. Q-wave MI was identified as a primary or secondary ICD-9-CM diagnosis code of 410.1 (AMI of other anterior wall), 410.2 (AMI of inferolateral wall), 410.3 (AMI of inferoposterior wall), 410.4 (AMI of other inferior wall), 410.5 (AMI of other lateral wall), 410.6 (true posterior wall infarction), 410.8 (infarction of atrium, papillary muscle, or septum alone), or 410.9 (AMI not otherwise specified). PCI with stent was identified as a primary or secondary ICD-9-CM procedure code of 30.06. Thrombolytic therapy was identified as a primary or secondary ICD-9 procedure code of 36.02, 36.04 (intracoronary artery thrombolytic infusion), 36.05, or 99.10 (injection or infusion of thrombolytic agent). The MedisGroups (CIC-Mediqual, Marlborough, MA) Admission Severity Groups (ASG) were used to risk adjust outcomes. The ASG is a discrete index of with 5 levels (0 to 4). The levels are associated with minimal, low, moderate, severe, and maximum risk of death at admission.[36–40]

Three measures of outcomes were available in the data set. Mortality was defined as in-hospital mortality. Length of stay included days from admission to either discharge or death. Charges were hospital charges billed to third party payers as reported on the UB-92 discharge form.

Statistical Methods

The statistical analysis was designed to: (1) describe the gender distribution of patients receiving PCI across all hospitals in Pennsylvania and, to control for access to PCI, in only those hospitals where PCI is available, (2) estimate the in-hospital mortality rate for men and women with AMI who were treated with PCI or who were medically managed both at hospitals that provided PCI and those that did not, (3) to control for other factors, such as age, race/ethnicity, severity, type of infarct, and source of admission in estimation of mortality, and (4) to estimate the incremental reduction in mortality attributable to the use of PCI in women after controlling selection bias attributable to observable factors.

We controlled for age in our regression models because it is well known that older patients are at greater risk of dying than younger patients, regardless of gender or treatment.[41] Similarly, we controlled for race/ethnicity since racial differences in mortality have been described for patients with AMI.[42] Patients with ST-segment elevation MI have better outcomes than patients with non-ST–segment elevation MI or bundle branch block MI.[43] We controlled for type of infarct using a dummy variable for Q-wave MI, which is an imperfect indicator of ST-segment elevation MI. Finally, patients with AMI often are transferred to hospitals where revascularization procedures are available.[44] These patients often have better outcomes either because of the care received at the transfer hospital or because of a selection effect whereby if a patient survives long enough to be transferred she is likely to have a good outcome. We controlled for source of admission using a dummy variable that indicated whether a patient was transferred from another facility.

Univariate comparisons were made between patient characteristics and outcomes using χ^2 tests for categorical variables and Student t test for continuous variables. Multivariate analyses of mortality were performed using multiple logistic regression. We estimated the incremental reduction in mortality attributable to PCI using propensity score matching.[45–47] This was done by first estimating a propensity score for each patient using logistic regression. A greedy matching algorithm was then used to match the propensity scores and select a matched control group of women who did not receive PCI but who had a similar distribution of characteristics as the women who received PCI. Propensity score methods were also used to select a control group of men who received PCI and who had a similar distribution of characteristics as women who received PCI. This comparison allowed us to determine whether outcomes could be expected to be similar if a gender gap were removed. Univariate comparisons of mortality were made between the propensity score matched groups using χ^2 tests.

RESULTS

In 2000, 10,170 (32.4%) AMI patients were treated with PCI and 21,181 (67.6%) patients were medically managed in Pennsylvania hospitals. Of these, 14,672 (46.8%) were women and 16,679 (53.2%) were men (Table 1). As seen in Table 1, women were older than men, had a higher severity score, and were less likely to be treated at a hospital offering PCI. Women were significantly less likely to receive PCI than men (23.9% vs. 40%, $P < 0.0001$).

Outcomes also were poorer for women, with a significantly higher in-hospital mortality rate for women treated at any hospital (12.7% vs. 9.7%, $P < 0.0001$; Table 2). Most of this difference in mortality, however, was the result of patients treated at hospitals where PCI was available. Women had a significantly higher mortality rate at these hospitals (10.% vs. 7.3%, $P = 0.0001$) and were significantly less likely to receive PCI (34.4% vs. 65.4%, $P < 0.0001$).

These disparities in treatment and outcomes were confirmed in multivariate analyses. After controlling for age, race/ethnicity, severity at admission, type of infarct, and source of admission, and limiting the analysis to include only hospitals where PCI was available, women still had 24% lower odds than men of undergoing PCI ($P < 0.0001$; Table 3). There were several other factors in addition to gender that were associated with PCI. Older patients and patients with greater severity scores were generally less likely to receive PCI, whereas patients transferred from other acute care facilities and those with Q-wave infarction were more likely to be treated with PCI.

To determine whether women who received PCI had superior outcomes to women who did not, we retrospectively matched women who received PCI to women who did not but who had a similar distribution of background characteristics. Results from the predictive model of PCI among women suggest a similar pattern of use of PCI as for men (Table 4, PCI model). Women with greater severity scores upon admission were less likely to be treated with PCI than women with lower severity scores, and older women were less likely to receive PCI than younger women. Women who were transferred from other acute care facilities were 3.4 times more likely to receive PCI ($P = 0.0001$), and patients with Q-wave infarctions were 2.25 times more likely to receive PCI ($P = 0.0001$). Using this predictive model, we created a

TABLE 1. Characteristics of Men and Women Treated for AMI in Pennsylvania in 2000

Variable	Men (n = 16,679)	Women (n = 14,672)	P
Age	67.6	75.3	0.0001
Race/ethnicity			
Black/Non-Hispanic	4.4%	5.6%	0.0001
White/Non-Hispanic	79.5%	79.7%	0.7317
Hispanic	0.9%	0.6%	0.0028
Other	15.1%	14.1%	0.0081
ASG Score	2.1	2.4	0.0001
ASG Score = 0	0.6%	0.2%	0.0001
ASG Score = 1	26.4%	10.9%	0.0001
ASG Score = 2	39.2%	38.9%	0.5408
ASG Score = 3	28.7%	43.2%	0.0001
ASG Score = 4	3.2%	4.7%	0.0001
Q-wave MI	57.5%	55.0%	0.0001
Transfer	18.2%	12.1%	0.0001
Emergent	64.3%	68.2%	0.0001
PCI hospital	75.4%	66.5%	0.0001
PCI	39.9%	23.9%	0.0001

ASG indicates Atlas Severity Group; PCI, percutaneous coronary interventions.

TABLE 2. Outcomes for Men and Women Treated for AMI in Pennsylvania (Mortality is Defined as In-Hospital Mortality)

Hospital	Outcome	Men	Women	P
All hospitals		(n = 16,679)	(n = 14,672)	
	Mortality*	9.7%	12.7%	0.0001
	LOS†	4.98	5.92	0.0001
	Charges‡	$25,374	$23,485	0.0001
Non-PCI hospitals		(n = 4,105)	(n = 4,920)	
	Mortality*	17.1%	17.8%	0.4006
	LOS†	5.94	6.37	0.0001
	Charges‡	$15,429	$14,931	0.1233
PCI hospitals		(n = 12,574)	(n = 9,752)	
	Mortality*	7.3%	10.1%	0.0001
	LOS†	4.67	5.69	0.0001
	Charges‡	$28,621	$27,800	0.0142

*In-hospital mortality.
†Length of stay from admission to discharge or death.
‡Total unadjusted charges.

TABLE 3. Variables That Affect the Likelihood of Receiving PCI

Variable	Coefficient	Odds Ratio	95% Confidence Lower	95% Confidence Upper	P
Intercept	2.14	—	—	—	0.0001
Female	−0.27	0.76	0.72	0.81	0.0001
White/Non-Hispanic	Reference				
Black/Non-Hispanic	−0.38	0.68	0.60	0.78	0.0001
Hispanic	−0.42	0.66	0.47	0.91	0.0118
Other race	0.12	1.13	1.04	1.22	0.0024
ASG score = 4	−2.11	0.12	0.09	0.16	0.0001
ASG score = 3	−0.97	0.38	0.35	0.41	0.0001
ASG score = 2	Reference				
ASG score = 1	0.28	1.33	1.22	1.44	0.0001
ASG score = 0	−1.35	0.26	0.18	0.38	0.0001
Q-wave MI	0.80	2.22	2.10	2.35	0.0001
Age	−0.04	0.96	0.96	0.96	0.0001
Transfer	1.03	2.80	2.60	3.02	0.0001
Emergent	−0.29	0.75	0.71	0.80	0.0001

Reference category for race/ethnicity is white/non-Hispanic. Reference category for severity is ASG score = 2. Reference category for emergent status is urgent status.
ASG indicates Atlas Severity Group; MI, myocardial infarction.

retrospectively matched cohort of women. Table 5 (PCI model) presents the characteristics of the cases and propensity score matched controls and shows that after matching, women who received PCI were slightly older (69.2 vs. 68.6, $P = 0.04$) and slightly more likely to have been transferred from another acute care facility (22.9% vs. 20.5%, $P = 0.025$). More importantly, as seen in Table 5, among the matched cohort, women who received PCI had a significantly lower mortality rate than similar women who did not (2.3% vs. 10.4%, $P = 0.0001$). They also had a shorter hospital stay (4.9 vs. 5.8, $P = 0.0001$) but significantly higher hospital charges ($37,930 vs. $19,595, $P = 0.0001$).

Finally, we created another propensity score-matched cohort to determine whether outcomes for women who received PCI differed from outcomes for a similar group of men who received PCI. The results of the predictive model are presented in Table 4 (gender model) and suggest that men who received PCI differed from women who received PCI in terms of race/ethnicity, severity, and age. Using the propensity scores from this model, we matched 3329 women treated with PCI to 3329 similar men who received PCI. As seen in Table 5 (gender model), matching produced 2 very similar groups in terms of background characteristics. None of the differences in characteristics between these men and women were statistically significant. Furthermore, outcomes for these patients suggest that there was no significant difference in mortality between men who received PCI and similar women who received PCI (1.59% vs. 1.92%, $P = 0.30$).

CONCLUSIONS

This analysis shows that in the Commonwealth of Pennsylvania in 2000, women were less likely than men to be treated for AMI with PCI, controlling for key covariates. Furthermore, women who received PCI were less likely to die than similar women who did not receive PCI. Finally, propensity score-matched women and men who received PCI had similar mortality. These results suggest that the morbidity and mortality associated with AMI in women could be reduced by increased use of PCI among women admitted for AMI.

TABLE 4. Variables That Affect the Likelihood of Receiving PCI Among Women Only (PCI Model) and Factors That Predict Female Gender Among Patients Receiving PCI (Gender Model)

	PCI Model					GENDER Model				
			95% Confidence					95% Confidence		
Variable	Coefficient	Odds Ratio	Lower	Upper	P	Coefficient	Odds Ratio	Lower	Upper	P
Intercept	2.17	—	—	—	0.0001	−2.58	—	—	—	0.0001
White/Non-Hispanic	Reference	—	—	—	—	Reference	—	—	—	—
Black/Non-Hispanic	−0.33	0.72	0.59	0.87	0.0007	0.49	1.63	1.32	2.01	0.0001
Hispanic	−0.52	0.59	0.33	1.08	0.0848	−0.3	0.74	0.42	1.3	0.3004
Other race	0.14	1.15	1.02	1.3	0.0266	−0.01	0.99	0.89	1.11	0.8922
ASG score = 4	−1.93	0.15	0.1	0.21	0.0001	0.39	1.48	0.9	2.44	0.1224
ASG score = 3	−0.87	0.42	0.38	0.47	0.0001	0.21	1.23	1.08	1.4	0.0015
ASG score = 2	Reference	—	—	—	—	Reference	—	—	—	—
ASG score = 1	0.05	1.05	0.91	1.21	0.4745	−0.36	0.7	0.62	0.79	0.0001
ASG score = 0	−1.4	0.25	0.11	0.58	0.0012	−0.13	0.88	0.44	1.78	0.724
Q-wave MI	0.81	2.25	2.07	2.46	0.0001	−0.07	0.93	0.85	1.02	0.1078
Age	−0.05	0.96	0.95	0.96	0.0001	0.03	1.03	1.03	1.04	0.0001
Transfer	1.21	3.36	2.99	3.78	0.0001	−0.02	0.98	0.89	1.08	0.6607
Emergent	−0.26	0.77	0.7	0.85	0.0001	−0.01	0.99	0.91	1.09	0.8733

Reference category for race/ethnicity is white/non-Hispanic. Reference category for severity is ASG score = 2. Reference category for emergent status is urgent status.
ASG indicates Atlas Severity Group; MI, myocardial infarction.

TABLE 5. Outcomes for Women With PCI Compared With Similar Women With PCI (PCI Model) and Outcomes for Men and Women Treated With PCI for AMI (Gender Model)

	PCI Model			GENDER Model		
Variable	No PCI (n = 3023)	PCI (n = 3023)	*P*	Men (n = 3329)	Women (n = 3329)	*P*
White/Non-Hispanic	77.20%	77.90%	0.5172	77.20%	77.50%	0.7923
Black/Non-Hispanic	5.30%	5.10%	0.6429	4.60%	4.50%	0.86
Hispanic	0.60%	0.50%	0.8614	0.30%	0.50%	0.0826
Other race	16.90%	16.50%	0.6788	17.90%	17.50%	0.6304
ASG score = 4	1.20%	1.20%	0.905	0.80%	0.80%	0.8923
ASG score = 3	22.20%	23.00%	0.4987	18.40%	18.00%	0.6798
ASG score = 2	53.10%	55.20%	0.1039	53.60%	54.30%	0.539
ASG score = 1	18.70%	18.90%	0.8435	25.80%	25.10%	0.5361
ASG score = 0	0.40%	0.30%	0.6692	0.10%	0.30%	0.1962
Q-wave MI	53.30%	54.40%	0.7693	55.90%	57.60%	0.1663
Age	68.6	69.2	0.0409	66.5	66.5	0.9064
Transfer	20.50%	22.90%	0.0246	29.90%	28.90%	0.3469
Emergent	56.30%	57.30%	0.4061	54.30%	55.20%	0.4756
Mortality	10.40%	2.30%	0.0001	1.59%	1.92%	0.3049
LOS	5.8	4.9	0.0001	4.2	4.7	0.0001
Charges	$19,595	$37,930	0.0001	$35,622	$37,155	0.0102

ASG indicates Atlas Severity Group, LOS, length of stay; MI, myocardial infarction.

These findings are important because they document a gender disparity in receipt of PCI and provide evidence of the effectiveness of PCI in women. Beyond the demonstration of a gender disparity in access to PCI, the findings show that increased use of PCI could reduce the gender disparity in mortality from AMI. These results contradict earlier assumptions that women undergoing PCI may be at increased risk, although the earlier evidence is from the mid-1980s.[48] It was also of interest that PCI was associated with both shorter hospital stay and higher charges, both of which provide incentives to providers for greater utilization. We did not have data on third-party reimbursement, which would more closely measure the incentive.

However, there are important limitations to this study. For example, although Pennsylvania is a large state with substantial rural and urban populations, the fact that the data were from a single state may limit the generalizability of the results. The data were from an administrative data set and lacked potentially important clinical information. For example, we were not able to differentiate between PCI used as primary treatment and PCI used as salvage therapy. Furthermore, there may be other clinical factors that drive the treatment decision that we were unable to control or account for. For example, the location of the infarct on the heart may be a factor of treatment decisions, as could be the particular vessels involved. If women were less likely to have disease of the left anterior descending artery or more disease of the circumflex system, this may be reason to opt for medical management. Also, type of infarct may drive treatment and outcomes. If the prevalence of S-T segment elevation infarctions is lower in women, this may explain why PCI was used less often and why outcomes were poorer for women. We were, however, able to control for Q-wave infarctions. But it may be argued that the Q-wave distinction is an older and less useful convention than ST-segment elevation infarction, and there may be concerns about proper coding in the data set. There may also be variation across hospitals in how myocardial necrosis is diagnosed. Although some hospitals may have used "older" assays to confirm the diagnosis of a myocardial infarction (eg, creatinine phosphokinase and isoenzymes) whereas other hospitals used current cardiac markers (ie, troponins), the definition of a MI would have remained unchanged throughout the study period. Finally, it should be noted that propensity score matching only controls for selection bias due to observable factors. Other variables related to the treatment decision that were not correlated with observable factor may still have an impact.

The strengths of this study include the fact that it is based on the total population of patients with AMI admitted to hospitals in one year. It also controlled for key covariates, such as age, severity, and race/ethnicity; and it used propensity scores to address selection bias.

On the basis of these results, providers should be alerted to the existence of possible gender bias in the provisional use of PCI. Although this study could not directly observe the reasons for women's lower receipt of PCI compared with men, the ability to control for age, severity, race/ethnicity, etc., in our analyses strengthens the case for possible gender biases on the part of physicians treating patients with AMI. Biases could affect treatment decisions if, for example, physicians believe that women are not good candidates for PCI or that women do not prefer this treatment. The results of this study also should reassure providers that women can be good candidates for PCI and that their clinical outcomes can be improved if PCI is provided similarly to men.

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