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ORIGINAL RESEARCH

Coronary Angiography and Intervention in Women Resuscitated From Sudden Cardiac Death

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BACKGROUND: Coronary artery disease is the primary etiology for sudden cardiac arrest in adults, but potential differences in the incidence and utility of invasive coronary testing between resuscitated men and women have not been extensively evaluated. Our aim was to characterize angiographic similarities and differences between men and women after cardiac arrest.

METHODS AND RESULTS: Data from the International Cardiac Arrest Registry–Cardiology database included patients resuscitated from out-of-hospital cardiac arrest of presumed cardiac origin, admitted to 7 academic cardiology/resuscitation centers during 2006 to 2017. Demographics, clinical factors, and angiographic findings of subjects were evaluated in relationship to sex and multivariable logistic regression models created to predict both angiography and outcome. Among 966 subjects, including 277 (29%) women and 689 (71%) men, fewer women had prior coronary artery disease and more had prior congestive heart failure (P=0.05). Women were less likely to have ST-segment–elevation myocardial infarction (32% versus 39%, P=0.04). Among those with ST-segment–elevation myocardial infarctions, identification and distribution of culprit arteries was similar between women and men, and there were no differences in treatment or outcome. In patients without ST-segment elevation post-arrest, women were overall less likely to undergo coronary angiography (51% versus 61%, P<0.02), have a culprit vessel identified (29% versus 45%, P=0.03), and had fewer culprits acutely occluded (17% versus 28%, P=0.03). Women were also less often re-vascularized (44% versus 52%, P<0.03).

CONCLUSIONS: Among cardiac arrest survivors, women are less likely to undergo angiography or percutaneous coronary intervention than men. Sex disparities for invasive therapies in post-cardiac arrest care need continued attention.

Key Words: cardiac arrest ■ coronary angiography ■ sex ■ women

Cardiovascular disease remains the number 1 cause of death in women.[1] Past studies have shown that women in the setting of acute coronary syndromes underwent coronary angiography and percutaneous coronary intervention (PCI) less often than men,[2,3] and their outcomes were reported to be significantly worse when compared with men.[4–6] Atypical presentations in women are now better understood and aggressively pursued, resulting in contemporary studies documenting substantial gains in the use of coronary angiography and the benefit from PCI in women with acute coronary syndromes.[7]

Considerably less is known about coronary artery disease in women suffering sudden cardiac death. Women experience cardiac arrest less often than men, are typically older in age, are more likely to have an initial non-shockable rhythm, are witnessed less often, and receive less bystander cardiopulmonary resuscitation (CPR) compared with men.[8–10] Karlsson et al[11] reported that men had a higher survival rate at hospital discharge compared with women after

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CLINICAL PERSPECTIVE

What Is New?

- Women are less likely to undergo coronary angiography post-cardiac arrest than men.
- In those receiving coronary angiography, a culprit vessel is less likely to be identified in women.
- However, the incidence of an acutely occluded culprit coronary vessel was similar for women and men.

What Are the Clinical Implications?

- The need for timely reperfusion of an acutely occluded coronary is not sex dependent.
- Women may be at risk for not receiving early coronary angiography and percutaneous coronary intervention since a greater proportion present with no ST-segment elevation post-cardiac arrest.

Non-standard Abbreviations and Acronyms

ACS	acute coronary syndromes
CPC	cerebral performance category
CPR	cardiopulmonary resuscitation
CTO	chronic total occlusion
DNR	do not resuscitate
ICU	intensive care unit
INTCAR	international cardiac arrest registry
IQR	interquartile range
PCI	percutaneous coronary intervention
ROSC	return of spontaneous circulation
STEMI	ST-segment–elevation myocardial infarction
TIMI	thrombolysis in myocardial infarction
TTM	targeted temperature management

out-of-hospital cardiac arrest. Several reports have shown that women are less likely to undergo coronary angiography after cardiac arrest,[12–15] including for shockable rhythms, and that in-hospital and 30-day mortality was higher for women compared with men.[8,12,13]

Emergent coronary angiography for patients with post-resuscitation electrocardiographic evidence of ST-segment–elevation myocardial infarction (STEMI), even when comatose, is the current standard of care. Early coronary angiography for such patients is a Class I recommendation by both the American College of Cardiology and the European Society of Cardiology.[16,17] Studies have shown that post-cardiac arrest patients with ST-segment elevation have a high prevalence of coronary artery disease, with 80% having an acutely occluded culprit coronary found at angiography.[18] However, these data have not been reported separately for women. Among those resuscitated, but without ST-segment elevation on their post-cardiac arrest ECG, angiography is recommended as reasonable for select adult patients with a high likelihood of a cardiac etiology for their sudden death.[19] Studies in this population have found about 25% to 30% have an acutely occluded culprit coronary but, again, sex-specific data are unavailable.[18,20–22] Finding an acutely occluded coronary in resuscitated patients is the primary purpose of performing early coronary angiography, even before their prognosis for neurological recovery can be fully assessed. Understanding the importance of timely reperfusion of an acutely occluded culprit coronary artery has led to world-wide acceptance of a door-to-balloon time metric of <90 minutes for STEMI patients.[16,17] Numerous reports involving cardiac arrest patients have shown that immediately post-resuscitation an acute coronary occlusion does not always produce ST-segment elevation.[18,20–24] Recognition of this phenomenon has led to enthusiasm for early coronary angiography post-resuscitation from cardiac arrest whether or not ST-segment elevation is present.[18,25–29] How often early coronary angiography is performed for men versus women survivors of cardiac arrest is not fully known,[12] and few data exist on the different coronary findings, including identification of acutely occluded coronary culprits early post-arrest between men and women.[30,31]

The aim of this study was to evaluate the invasive treatment of women resuscitated from cardiac arrest, with specific attention to the details of their coronary angiographic findings and percutaneous intervention treatment, while comparing their outcomes with men. We hypothesized that clinical, arrest-specific, and coronary angiographic differences exist between women and men. We also hypothesized that there would be a difference in the acute coronary management of patients between men and women.

METHODS

Patients

This was an observational, registry-based study of cardiac arrest survivors, conducted in the INTCAR (International Cardiac Arrest Registry) Cardiac Sub-Registry. The INTCAR Cardiology Research Group consists of 7 United States interventional cardiology centers that prospectively or retrospectively completed the standard 87-point INTCAR data set, plus an additional 56 data points specific to cardiac

testing, results, and treatments. The institutional review board of each institution approved data collection and participation, and INTCAR approved the registry-based project with a waiver of informed consent; data analysis was performed at Maine Medical Center. The data that support the findings of this study are available from the corresponding author upon reasonable request. Patients were composed of unconscious (Glasgow Coma Scale motor score <6), adult (≥18 years) patients admitted to the intensive care unit following return of spontaneous circulation after out-of-hospital cardiac arrest with a presumed cardiac etiology for their arrests. Presumed cardiac origin was defined as "an arrest is presumed to be of cardiac etiology unless it is known, obvious or likely to have been of other cause." The study period was 2006 to 2017. Centers were asked to register patients consecutively, and each center treated its patients per their own therapeutic protocols, cardiac care pathways, and targeted temperature management equipment.

Data

Data collection on patient characteristics, comorbidities, cardiac arrest-related factors, and time points followed the Utstein recommendations. Our general methodology for using the INTCAR registry has been previously published.[11,18,24,32–34] Cardiac arrest data were recorded from ambulance and emergency medical services records, using standardized definitions. The database provided automatic range checks and all entries were manually reviewed for plausibility and logic. Site investigators were contacted to clarify data when appropriate. On-site monitoring was not performed. Data related to intensive care management, cardiac interventions, coronary angiography, and adverse events were recorded according to a pre-defined protocol, and angiographic data were entered by cardiology fellows supervised by attending interventional cardiologists. Shock was defined as (1) Hypotension (a systolic blood pressure <90 mm Hg for at least 30 minutes or the need for supportive measures to maintain a systolic blood pressure ≥90 mm Hg) and (2) End-organ hypoperfusion (cool extremities or a urine output <30 mL/h, and a heart rate of >60 beats per minute).

We further assessed the use of targeted temperature management, cardiac catheterization, PCI, PCI complications, use of do not resuscitate orders, and the withdrawal of life support measures. Coronary angiography-related data were reviewed by attending interventional cardiologists for quality control purposes, and these individuals were personally responsible for data quality and correctness. Angiograms were reviewed for "culprit vessels", defined as a major coronary vessel with TIMI 0 flow or an irregular, eccentric, high-grade coronary stenosis that might have a narrow neck, acute angles or craters, thought to represent either disrupted plaque or partially occlusive thrombus. When a culprit was identified it further classified as acutely occluded or not. "Acutely occluded" was defined as TIMI 0 anterograde flow with angiographic evidence of occlusive thrombus at the site of the occlusion or by the ability to pass a standard intracoronary guidewire easily through the occluded segment. If such an intracoronary wire would not easily be advanced across the occlusion the vessel was considered not an acutely occluded culprit, but rather a chronic total occlusion.

Outcome Measurements

Survival to discharge from the hospital and neurological function at discharge were recorded. According to convention, neurological outcome was assessed in terms of Cerebral Performance Category (CPC): CPC 1 indicates no or minor neurologic disability; CPC 2 indicates conscious, with moderate neurologic disability, and able to work; CPC 3 indicates conscious, severe neurologic disability, and dependent; CPC 4 indicates coma or vegetative state; and CPC 5 indicates dead. A classification of CPC 1 or 2 was regarded as a favorable neurologic outcome. Follow-up outcome was measured at 6 months by phone using CPC.

Statistical Analysis

Continuous variables are presented with median and interquartile range. Groups that were not normally distributed were compared using the Mann–Whitney *U* test. Binary outcomes are presented as counts and percentages and were analyzed using the Chi-square test. All *P* values are 2-tailed, and a $P<0.05$ was considered significant.

Multivariable logistic regression models were created to evaluate the association of sex with the odds ratio of receiving angiography in patients without ST-segment elevation, and the association of sex with outcome at hospital discharge in all patients. Candidate variables were selected a priori and continuous variables were tested for linearity. A univariate screen was performed first, and variables were retained if they met a $P<0.2$ threshold. The angiography model adjusted for sex, bystander CPR, and witnessed arrest, time to return of spontaneous circulation (ROSC), and shockable rhythm. The outcome model adjusted for sex, bystander CPR, witnessed arrest, time to ROSC, presence of STEMI, shockable rhythm, angiography, and PCI. Goodness-of-fit for the logistic regression model was assessed using the Hosmer–Lemeshow

test and an adequate fit was assumed if $P>0.05$. Odds ratios reflect the odds for patients receiving an angiogram, for survival to hospital discharge, and for a good neurological outcome at hospital discharge, respectively. Statistical analyses were performed using R software version 1.2.1335.

RESULTS

There were 966 patients in the INTCAR-cardiology registry between the years 2006 to 2017. This included 277 (29%) women and 689 (71%) men, with a median age of 62 years for women and 63 years for men (Figure 1). The majority of both men and women had witnessed arrests (80% women versus 82% men). The proportions receiving bystander CPR were also not different (50% versus 54%). Women were more likely to have a history of heart failure, and men were more likely to have a prior history of known coronary artery disease (Table 1).

The rate of treatment with targeted temperature management was similar between women and men, with 95% of women and 96% of men. There were identical rates of women and men treated to a target temperature range of 32°C to 34°C (91% and 91%), as well as to a target temperature range of 35°C to 37°C (3% versus 3%).

Missing Data

The overall rate of missing data is low. The variable with the most missing data was outcome at follow-up at a rate of 15% and time to professional CPR at 13%, followed by time to ROSC with a rate of 7% missing data. The exploratory variable of sex had zero missing data. Missing outcome at hospital discharge was 0.3% and follow-up as above. Incidence of missing data for the variables of angiography, culprit vessel, were zero and percutaneous coronary intervention had no missing data. There were no significant differences in the incidence of missing data by sex (Figure S1).

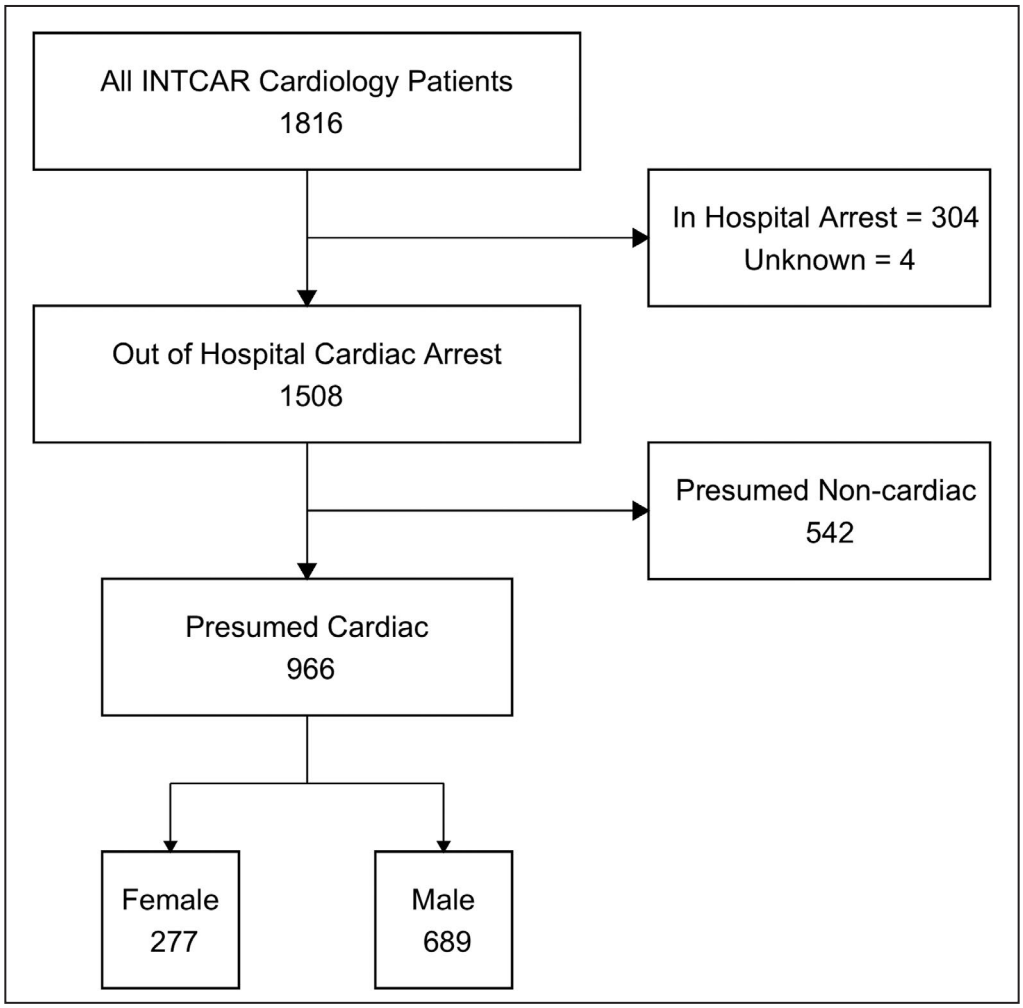

Figure 1. Consort diagram of INTCAR cardiology.
INTCAR indicates International Cardiac Arrest Registry.

Table 1. Demographics and Arrest Characteristics

Characteristic*	F, n=277	M, =689	*P* Value†
Age, y	62 (51, 71)	63 (54, 73)	0.09
Coronary artery disease	74 (27%)	235 (34%)	0.03
Congestive heart failure	63 (23%)	113 (16%)	0.03
Arrhythmia	44 (16%)	110 (16%)	0.98
Chronic kidney disease	33 (12%)	76 (11%)	0.80
Liver disease	4 (1.4%)	9 (1.3%)	0.90
Insulin-dependent DM	29 (10%)	58 (8.4%)	0.40
Non-insulin dependent DM	39 (14%)	105 (15%)	0.70
Obese	42 (15%)	88 (13%)	0.40
COPD	39 (14%)	75 (11%)	0.20
Hypertension	157 (57%)	378 (55%)	0.70
Shockable rhythm	186 (97%)	519 (97%)	0.90
Witnessed	220 (80%)	560 (82%)	0.66
Bystander CPR	138 (50%)	372 (54%)	0.32
Time to EMS CPR	7 (4, 11)	6 (4, 10)	0.55
Any defibrillation	217 (80%)	579 (85%)	0.08
Time to ROSC	20 (13, 39)	22 (14, 34)	0.82

COPD indicates chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; DM, diabetes mellitus; EMS, emergency medical system; and ROSC, return of spontaneous circulation.

*Statistics presented: median (interquartile range); n (%).

†Statistical tests performed: Wilcoxon rank-sum test; Chi-square test of independence; Fisher exact test.

Post-Resuscitation ECG Findings

The rate of ST-segment elevation differed by sex, with 32% of women having ST-segment elevation and 39% of men ($P<0.04$). The location of ST-segment elevation did not differ significantly between women and men (Table 2).

Patients With Shock

There were no differences between women and men in the incidence of shock. Patients with shock had similar rates of undergoing angiogram and also showed similar rates of having a culprit lesion found on angiogram and receiving PCI (Table 3).

Post-Resuscitation Coronary Angiographic Findings

A significantly lower proportion of women underwent coronary angiography (63% versus 73%, $P<0.001$). Of patients who went to coronary angiography, fewer culprit lesions were identified in female patients (54% versus 64%, $P=0.04$), but the rates of culprit vessel occlusion were similar (75% versus 80%, $P=0.48$) in women and men. The lower rates of both coronary angiography and identified culprit vessels in women were due entirely to such differences in the subgroup of women with non–ST-segment–elevation myocardial infarction; women with STEMI findings on initial ECG had equal rates of both coronary angiography and identified culprit vessels as did men (Table 4).

Table 2. Post-Resuscitation ECG Findings for Patients With STEMI by Sex

Patients With STEMI*	Women, n=88	Men, n=270	*P* Value†
STEMI	88/277 (32%)	270/689 (39%)	0.04
STE location anterior	36 (59%)	110 (60%)	0.98
STE location inferior	35 (55%)	110 (60%)	0.49
STE location lateral	14 (29%)	48 (35%)	0.47
STE location posterior	3 (6.2%)	13 (10%)	0.53
STE location left bundle	5 (10%)	11 (8.1%)	0.53

STEMI indicates ST-segment–elevation myocardial infarction; STE, ST segment elevation.

*Statistics presented: (%); Multiple ST-segment–elevation locations were allowed.

†Statistical tests performed: Chi-square test of independence.

Post-Resuscitation PCI

Among patients with culprit lesions identified, females were less likely to receive PCI treatment than men (44% versus 52%, $P=0.029$) and trended toward being less likely to receive a drug eluting stent as opposed to other PCI therapy (13% versus 20%, $P=0.06$), a finding that was consistent, regardless of whether or not patients had an STEMI pattern on ECG. The complications of PCI were similar between the 2 groups (Table 5).

Outcomes

Survival data are shown in Table 6. Survival to hospital discharge was similar in women and men patients (50% versus 52%). Favorable CPC at hospital discharge and delayed follow-up was also similar in female and male patients. These findings did not differ based on the presence or absence of ST-elevations on the initial ECG. Women underwent withdrawal of life sustaining therapies at the same rate as men. After adjustment for confounders, multivariable logistic regression modeling showed sex to be an independent predictor of receiving angiography, but not of outcome (Table 7). Both the model for receiving angiography and outcome had a non-significant Hosmer–Lemeshow test ($P=0.64$ and 0.13, respectively), indicating the models had adequate prediction.

DISCUSSION

This retrospective observational registry study demonstrated women resuscitated from out-of-hospital cardiac arrest and admitted to comprehensive cardiology centers were somewhat less likely to have STEMI at the time of presentation. Among patients with shockable initial rhythms but without ST-segment elevation, women

Table 3. Interventions of Patients With Shock by Sex

All Patients*	Women, n=277	Men, n=689	*P* Value†
Any shock	142 (51%)	360 (52%)	0.87
Patients with shock who went to angiography	38 (14%)	110 (16%)	0.42
Patient with shock who had culprit lesion	28 (10%)	76 (11%)	0.76
Patients with shock who had PCI	55 (24%)	169 (28%)	0.33
Any device support for shock	23 (8.3%)	76 (11%)	0.34
Patients With STEMI*	**Women, n=88**	**Men, n=270**	***P* Value†**
Any shock	55 (62%)	159 (59%)	0.62
Patients with shock who went to angiography	23 (26%)	67 (25%)	0.98
Patient with shock who had culprit lesion	19 (22%)	57 (21%)	0.95
Patients with shock who had PCI	38 (45%)	114 (45%)	0.97
Any device support for shock	13 (15%)	45 (17%)	0.79
Patients Without ST-Segment–Elevation*	**Women, n=189**	**Men, n=419**	***P* Value†**
Any shock	87 (46%)	201 (48%)	0.68
Patients with shock who went to angiography	15 (7.9%)	43 (10%)	0.54
Patient with shock who had culprit lesion	9 (4.8%)	19 (4.5%)	0.92
Patients with shock who had PCI	17 (11%)	55 (15%)	0.29
Any device support for shock	10 (5.3%)	31 (7.4%)	0.43

PCI indicates percutaneous coronary intervention.
*Statistics presented: n (%).
†Statistical tests performed: Chi-square test of independence.

less often underwent coronary angiography, and when they did so they were less likely to have a culprit lesion identified. Among the patients who did have culprit lesions, women were less likely to undergo stenting, or to receive drug-eluting stents. PCI rates in women with STEMI were similar to those of men. Finally, after extensive correction for confounding, female sex was independently associated with a lower rate of cardiac catheterization. These findings suggest that women resuscitated from cardiac arrest are somewhat different than men, in terms of etiology and pathophysiology, and that there are significant differences in therapies used. The reasons for and implications of these treatment differences cannot be determined from these data, and deserve further study.

There are some demographic and clinical differences based on sex. Similar to other studies, our cohort had many fewer women than men. This

Table 4. Post-Resuscitation Coronary Angiographic Findings

All Patients*	Women, n=277	Men, n=689	*P* Value†
Patients who went to angiography	175/277 (63%)	506/689 (73%)	<0.01
Culprit identified	95/175 (54%)	322/506 (64%)	0.04
Culprit occluded	72/95 (76%)	257/322 (80%)	0.48
Occluded culprit and underwent angiography	72/175 (41%)	257/506 (51%)	0.04
Patients With STEMI*	**Women, n=88**	**Men, n=270**	***P* Value†**
Patients who went to angiography	78/88 (89%)	250/270 (93%)	0.39
Culprit identified	67/78 (86%)	207/250 (83%)	0.89
Culprit occluded	56/67 (84%)	185/207 (89%)	0.25
Occluded culprit and underwent angiography	56/78 (72%)	185/250 (74%)	0.70
Patients Without ST-Segment Elevation*	**Women, n=189**	**Men, n=419**	***P* Value†**
Patients who went to angiography	97/189 (51%)	256/419 (61%)	0.02
Culprit identified	28/97 (29%)	115/256 (45%)	0.03
Culprit occluded	16/28 (57%)	72/115 (63%)	0.60
Occluded culprit and underwent angiography	16/97 (17%)	72/256 (28%)	0.03

*Statistics presented: n (%).
†Statistical tests performed: Chi-square test of independence.

Table 5. Post-Resuscitation PCI for Patients Who Underwent Angiography by Sex

All Patients*	Women, n=164	Men, n=470	*P* Value†
PCI done	72 (44%)	245 (52%)	0.03
Patients with culprit lesion with PCI	70 (43%)	229 (49%)	0.22
Drug-eluting stent	21 (13%)	93 (20%)	0.06
Any PCI complication	15 (9.0%)	40 (8.5%)	0.94
PCI dissection	2 (1.2%)	1 (0.2%)	0.18
STEMI Patients*	**Women, n=70**	**Men, n=207**	***P* Value†**
PCI done	50 (71%)	151 (73%)	0.84
Patients with culprit lesion with PCI	50 (71%)	146 (71%)	0.94
Drug-eluting stent	13 (19%)	54 (26%)	0.33
Any PCI complication	9 (13%)	24 (12%)	0.79
PCI dissection	1 (1.4%)	1 (0.5%)	0.42
Patients Without ST-Segment Elevation*	**Women, n=94**	**Men, n=263**	***P* Value†**
PCI done	22 (23%)	93 (35%)	0.02
Patients with culprit lesion with PCI	20 (21%)	82 (31%)	0.07
Drug-eluting stent	8 (8.5%)	39 (15%)	0.22
Any PCI complication	6 (6.4%)	16 (6%)	0.95
PCI dissection	1 (1.1%)	0 (0%)	0.27

PCI indicates percutaneous coronary intervention.
*Statistics presented: n (%).
†Statistical tests performed: Chi-square test of independence; Fisher exact test.

could be because of a lower incidence of disease, to lower rates of successful resuscitation, or both. Resuscitated women less often had prior coronary artery disease, but more often preceding heart failure than men. The age of resuscitated women was numerically but not statistically lower than men. Finally, the initial ECG of women less often showed STEMI than men (Table 1). The other demographic

Table 6. Outcome and Withdraw Practices by Sex

All Patients*	Women, n=277	Men, n=689	*P* Value†
Survival to hospital discharge	139 (50%)	357 (52%)	0.73
CPC 1 or 2 at discharge	115 (42%)	309 (57%)	0.18
CPC at follow-up	103 (37%)	283 (47%)	0.22
Withdrawal of life support	128 (46%)	289 (43%)	0.34
Early withdrawal of life sustaining therapies	54 (19%)	118 (24%)	0.28
Patients With STEMI*	**Women, n=88**	**Men, n=270**	***P* Value†**
Survival to hospital discharge	46 (52%)	140 (52%)	0.96
CPC 1 or 2 at discharge	41 (46%)	119 (44%)	0.73
CPC at follow-up	30 (34%)	105 (39%)	0.79
Withdrawal of life support	38 (43%)	112 (41%)	0.78
Early withdrawal of life sustaining therapies	25 (28%)	50 (19%)	0.14
Patients Without ST-Segment Elevation*	**Women, n=189**	**Men, n=419**	***P* Value†**
Survival to hospital discharge	93 (49%)	217 (52%)	0.63
CPC 1 or 2 at discharge	74 (39%)	190 (45%)	0.08
CPC at follow-up	73 (39%)	178 (43%)	0.32
Withdrawal of life support	90 (48%)	177 (28%)	0.34
Early withdrawal of life sustaining therapies	29 (15%)	68 (16%)	0.96

CPC indicates Cerebral Performance Category; EWLST, early withdrawal of life sustaining therapies (before hospital day 3); and STEMI, ST-elevation–myocardial infarction.
*Statistics presented: n (%).
†Statistical tests performed: Chi-square test of independence.

Table 7. Hierarchical Logistic Regression Models: Adjusted Model for Factors Associated With Undergoing Coronary Angiography Among Patients Without an STEMI

	OR	95% CI	*P* Value
n=536			
Women	0.13	0.04–0.37	0.01
Age, y	1.01	1.00–1.02	0.25
Time to ROSC	0.99	0.98–1.01	0.52
Defibrillation	1.44	0.81–2.56	0.22
Shockable rhythm	6.4	3.61–11.34	<0.01
Witnessed arrest	1.35	0.84–2.12	0.21
n=875			
Women	1.32	0.79–1.61	0.49
Bystander CPR	1.47	1.07–2.03	0.01
Witnessed arrest	1.62	1.00–2.70	0.06
Time to ROSC	0.95	0.94–0.96	<0.01
Shockable rhythm	4.76	3.06–7.39	<0.01
STEMI	0.92	0.64–1.32	0.63
Angiography	1.45	1.02–2.09	<0.01
PCI	1.29	0.90–1.86	0.16

Adjusted model for factors associated with good outcome in all patients. CPR indicates cardiopulmonary resuscitation; OR, odds ratio; PCI, percutaneous coronary intervention; ROSC, return of spontaneous circulation; and STEMI, ST-segment–elevation myocardial infarction.

and clinical features of resuscitated women and men did not differ by sex.

Women resuscitated from cardiac arrest underwent early coronary angiography post-cardiac arrest significantly less often than men. In the overall population, this difference was highly significant (Table 4)—driven not by STEMI patients, among whom the majority of both women and men had early coronary angiography, but by patients without ST-segment elevation. In this subgroup, 51% of women underwent early coronary angiography, while 61% of men had an early or emergent cardiac catheterization (Table 4). This finding highlights the continued disparity in invasive evaluation of coronary disease in women. An editorial about the ongoing sex disparity in cardiac care notes 1 potential contributing factor is the persistent perception among healthcare providers that coronary artery disease is a male phenomenon.[35]

Our results differ from Lindgren et al,[31] who identified 1498 patients with out-of-hospital cardiac arrest with shockable rhythms who were resuscitated and admitted comatose to the hospital. Forty percent had cardiac arrest associated with an STEMI, while 60% had non–ST-segment–elevation myocardial infarction on their post-resuscitated ECG. Women comprised 22% of the study population, and there were no sex differences in the use of coronary angiography within the first 24 hours of hospitalization (40% versus 45%),[31] or in the proportion of women and men without ST-elevation in regard to the use of coronary angiography (24% versus 30%). These differences may be a reflection of the different study populations, as they included only those with ventricular fibrillation or pulseless ventricular tachycardia.

During early coronary artery angiography, we found fewer culprit vessels in women than men (Table 4). Again, this was primarily attributable to the subgroup of patients without ST-segment elevation, as culprit lesion rates were similar among the STEMI patients. Finding a culprit vessel at catheterization post-arrest is obviously influenced by the proportion of patients with STEMI versus no ST-segment elevation. As such, women are at risk of being considered less ideal candidates for early coronary angiography post-arrest since they are less likely to have ST-segment elevation. It is also true that lower rates of culprit lesions in women without STEMI were found in our study and could suggest a different risk/benefit profile for women, making different angiography rates defensible. Whether lower rates of early catheterization in women without ST-segment elevation post-arrest are driven by an appropriate weighting of risks in individual patient, or by unconscious bias is unknown, but should be explored.

In our study, women also received less PCI following cardiac catheterization post-cardiac arrest. The utility of early coronary angiography post-cardiac arrest is to identify culprit vessels responsible for the arrest and intervene to salvage infarcting myocardium and prevent further ischemic complications, including re-arrest in the future. This is particularly important if the culprit vessel is acutely occluded. Timely reperfusion with PCI can then be done to limit myocardial damage and preserve ventricular function. Delayed or no coronary angiography in cases where the culprit vessel is acutely occluded results in loss of any chance for meaningful reperfusion therapy. Similar to non-cardiac arrest acute coronary syndromes, if significant myocardial salvage is accomplished, long-term outcomes should be better.

We found no difference in the incidence of the identified culprit vessel being acutely occluded between women and men for all patients, among those with STEMI, or among those without ST-segment elevation (Table 4).

Similar to calculating the number need to be treat, it is helpful to calculate the number of individuals needed to undergo coronary angiography to find an acutely occluded culprit vessel post-arrest. In the total population, this ratio is 1 culprit for every 2.4 women undergoing angiography, and 1 for every 2 men. In those with cardiac arrest associated with an STEMI, we found 1 culprit vessel for every 1.4 women undergoing early coronary angiography. In men with STEMI it was also 1 culprit for every 1.4 men taken for cardiac catheterization. In women without ST-segment elevation it was 1 in

5.9, and for men with no ST-segment elevation it was 1 in 3.6 (Figure 2). Though the highest number of angiograms needed to find a culprit is in women without ST elevation, the number of 6 coronary angiograms to find 1 acutely occluded vessel is not inconsequential and suggests that early angiography should be considered in women post-arrest without ST-segment elevation.

There were no differences detected in PCI technique—with a trend toward less usage of drug-eluting stents—or procedural complications in women and men undergoing PCI post-cardiac arrest (Table 5). Nor were there any differences for survival to hospital discharge or favorable neurological function upon discharge (Table 6).

Limitations

The major limitation to our study is the uniqueness of the patient population. Only patients who were successfully resuscitated and admitted for aggressive post-arrest care were included in this study. Enrolling centers were expected to use temperature management and early coronary angiography. The high rate of targeted temperature management (92%–95%) is strong evidence that such expectations were achieved. Hence, the applicability of the data to all women and men suffering cardiac arrest could be questioned. However, among those cardiac arrest victims fortunate enough to be initially resuscitated, the data suggests we still need to better understand the factors leading to diagnostic and therapeutic decisions, and verify we are providing equitable and optimal post-cardiac arrest care to all patients. Lastly, in an attempt to describe the data as thoroughly as possible, several analyses were performed, and we did not adjust for multiple testing. Therefore, these results are hypothesis generating and should be further explored in other clinical or trial data sets.

CONCLUSIONS

Women successfully resuscitated from cardiac arrest undergo early coronary angiography and acute PCI less often than men. Among women undergoing coronary angiography after cardiac arrest, fewer culprit vessels are found than in men, but the same proportion are acutely occluded as in men. The need for timely reperfusion to salvage ischemic myocardium is not sex dependent, and more attention needs to be paid to women and the potential benefit of early catheterization post-arrest. Women may be at risk of not receiving early coronary angiography and PCI for culprit vessels because a greater proportion present without ST-elevation post-cardiac arrest, potentially biasing angiographers who anticipate a lower incidence of culprit artery occlusions. Sex disparities in invasive diagnosis and interventional treatments may still exist for women successfully resuscitated from out-of-hospital cardiac arrest, and must be better understood to optimize practices and outcomes.

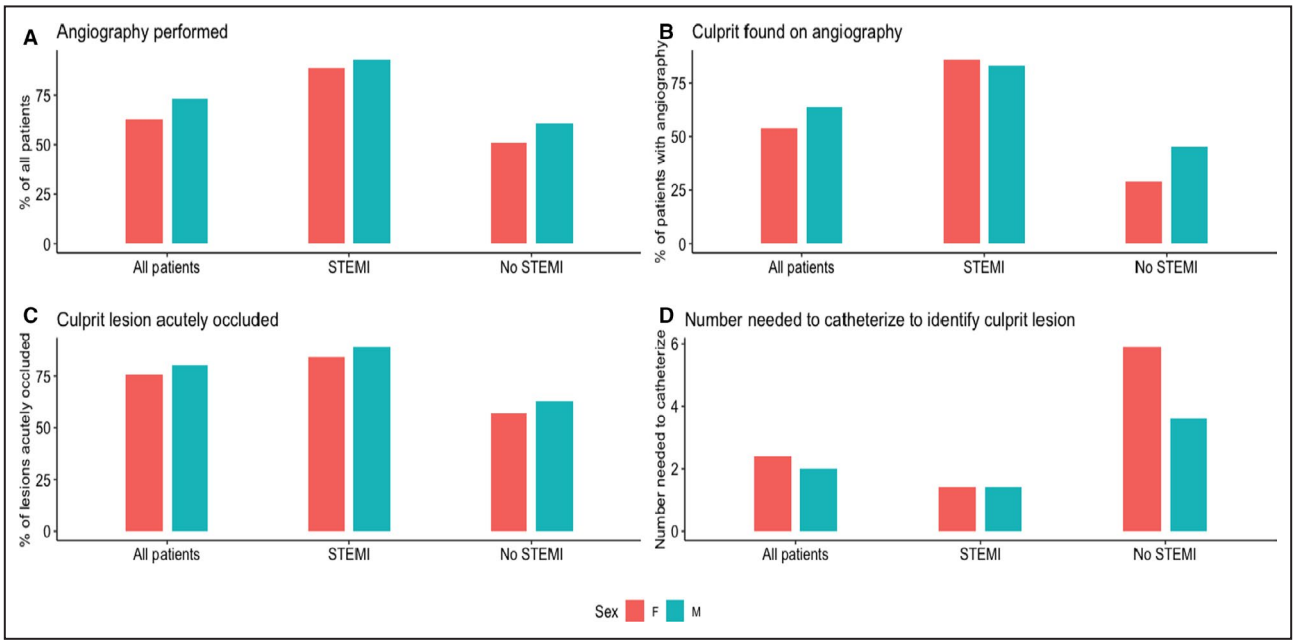

Figure 2. Angiographic data for all patients, those with ST-segment–elevation myocardial infarction, and those without ST-segment elevation by sex.

A, Percentage of patients where angiography was performed; (**B**) Percentage of patients who underwent angiography found to have culprit lesion, (**C**) Percentage of patients with a culprit coronary artery acutely occluded, (**D**) Number of patients undergoing early coronary angiography to find one acutely occluded culprit vessel. STEMI indicates ST-segment–elevation myocardial infarction.

ARTICLE INFORMATION

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None.

Supplementary Materials

Figure S1

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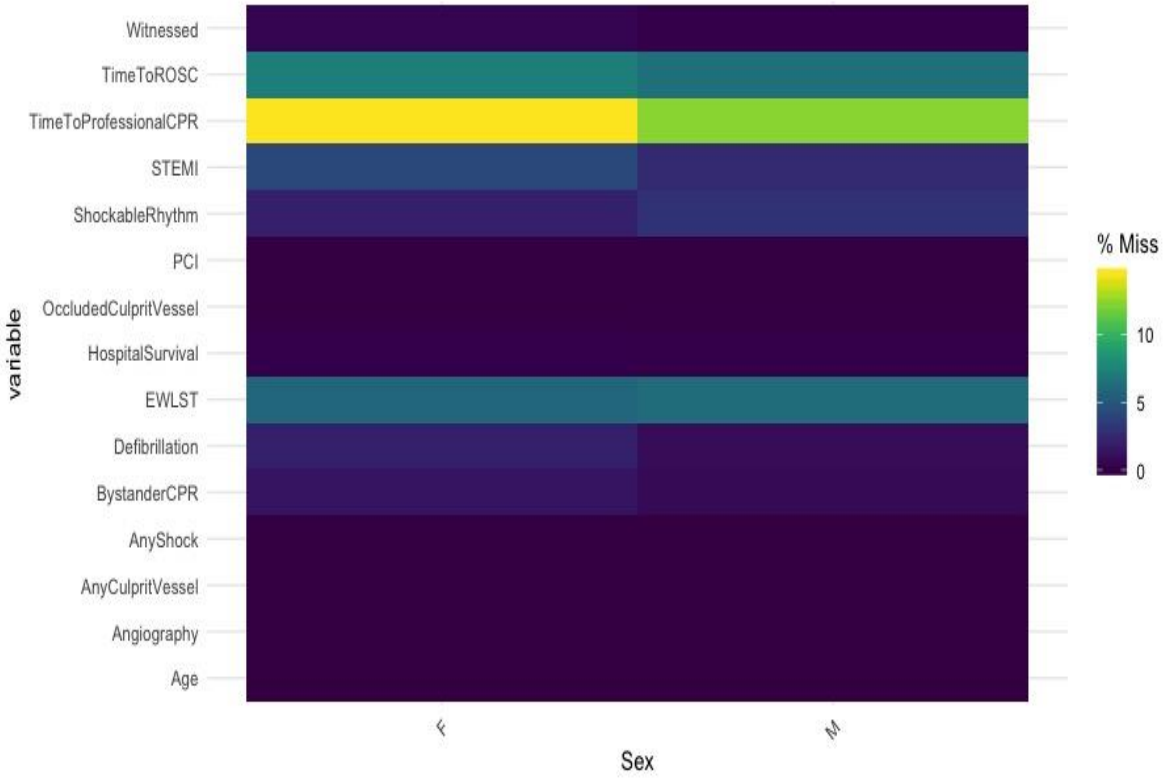
SUPPLEMENTAL MATERIAL

Figure S1. Missing data between Female and Male.



EWLST = Early withdrawal of life sustaining therapies (before hospital day 3), PCI = percutaneous coronary intervention, ROSC = return of spontaneous circulation, STEMI = ST elevation myocardial infarction