Outcomes of Comatose Cardiac Arrest Survivors With and Without ST-Segment Elevation Myocardial Infarction: Importance of Coronary Angiography.

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Outcomes of Comatose Cardiac Arrest Survivors With and Without ST-Segment Elevation Myocardial Infarction

Importance of Coronary Angiography

ABSTRACT

OBJECTIVES The aim of this study was to compare outcomes and coronary angiographic findings in post-cardiac arrest patients with and without ST-segment elevation myocardial infarction (STEMI).

BACKGROUND The 2013 STEMI guidelines recommend performing immediate angiography in resuscitated patients whose initial electrocardiogram shows STEMI. The optimal approach for those without STEMI post-cardiac arrest is less clear.

METHODS A retrospective evaluation of a post-cardiac arrest registry was performed.

RESULTS The database consisted of 746 comatose post-cardiac arrest patients including 198 with STEMI (26.5%) and 548 without STEMI (73.5%). Overall survival was greater in those with STEMI compared with those without (55.1% vs. 41.3%; $p = 0.001$), whereas in all patients who underwent immediate coronary angiography, survival was similar between those with and without STEMI (54.7% vs. 57.9%; $p = 0.60$). A culprit vessel was more frequently identified in those with STEMI, but also in one-third of patients without STEMI (80.2% vs. 33.2%; $p = 0.001$). The majority of culprit vessels were occluded (STEMI, 92.7%; no STEMI, 69.2%; $p < 0.0001$). An occluded culprit vessel was found in 74.3% of STEMI patients and in 22.9% of no STEMI patients. Among cardiac arrest survivors discharged from the hospital who had presented without STEMI, coronary angiography was associated with better functional outcome (93.3% vs. 78.7%; $p < 0.003$).

CONCLUSIONS Early coronary angiography is associated with improved functional outcome among resuscitated patients with and without STEMI. Resuscitated patients with a presumed cardiac etiology appear to benefit from immediate coronary angiography. (J Am Coll Cardiol Intv 2015;8:1031–40) © 2015 by the American College of Cardiology Foundation.

Cardiac arrest remains a major public health issue in the United States. After decades of dismal overall national survival rates of only 5% to 7% (1), progress is finally been realized. Several new and innovative systematic approaches to resuscitation, such as cardiocerebral resuscitation with chest compression-only cardiopulmonary resuscitation (2) and Take Heart America (3) have led the way to improving long-term survival.

The next important step for further improving survival of cardiac arrest is post-resuscitation care. Aggressive post-cardiac arrest care, including targeted temperature management (TTM) and coronary artery reperfusion, can double the number of out-of-hospital cardiac arrest patients surviving to hospital discharge (4,5). French investigators showed that 70% of those resuscitated from out-of-hospital cardiac arrest and taken immediately to coronary angiography (CAG) have coronary artery disease. They found that nearly 50% of such resuscitated patients have an acutely occluded coronary vessel (6). The assumption is that such an acute coronary occlusion was the likely trigger of the cardiac arrest. If the majority of adult out-of-hospital cardiac arrests are precipitated by an acute ischemic event, particularly an acute coronary occlusion, then the strategy of immediate coronary angiography with potential percutaneous coronary intervention (PCI) seems appropriate. Timely reperfusion of acute coronary occlusions in nonarrested patients has been proved to improve both left ventricular function and survival.

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When an acutely occluded coronary vessel is responsible for triggering cardiac arrest, systemic circulation must be restored by cardiopulmonary resuscitation and defibrillation, followed by timely reperfusion of the culprit coronary vessel to prevent rearrest or hemodynamic collapse and to preserve myocardial function.

Recently, both the European Society of Cardiology and the American College of Cardiology Foundation with the American Heart Association new STEMI guidelines addressed appropriate treatments for STEMI patients experiencing cardiac arrest (7,8). Each recommended starting targeted temperature management early in comatose patients with STEMI and out-of-hospital cardiac arrest, including patients who undergo primary PCI (Class I recommendation). They also stated that immediate angiography, and PCI when indicated, should be performed in resuscitated out-of-hospital cardiac arrest patients whose initial electrocardiogram (ECG) shows STEMI (Class I recommendation). The European Society of Cardiology added another recommendation that "immediate angiography with a view to primary PCI should be considered in survivors of cardiac arrest without diagnostic ECG ST-segment elevation but with a high suspicion of ongoing infarction" (Class IIA recommendation) (7). The American Heart Association cardiopulmonary resuscitation guidelines in 2010 had previously recommended that "It is reasonable to perform early angiography and PCI in selected patients despite the absence of ST-segment elevation on the ECG … if coronary ischemia is considered the likely cause [of the cardiac arrest] on clinical grounds" (9). Nonetheless, the interventional cardiology community in the United States has been slow to adopt the recommendation to perform immediate coronary angiography for those without STEMI post-resuscitation.

We reviewed the International Cardiac Arrest (INTCAR) cardiology registry (10,11) to examine clinical outcomes and specific findings at coronary angiography among those with and without STEMI post–cardiac arrest. The aim of this study was to determine whether immediate coronary angiography after resuscitation was associated with improved survival in those with and without STEMI and whether the associated coronary anatomic findings in these 2 patient groups could help explain why early CAG and PCI are associated with improved outcomes.

METHODS

The INTCAR registry, comprising 34 centers in Europe and the United States, describes the characteristics and outcomes of post-resuscitation cardiac arrest care. It consists of 87 "core" data points including demographic characteristics, pre-arrest conditions, resuscitation characteristics, post-resuscitation therapies including TTM, and outcomes including survival to discharge and delayed functional outcome after hospital discharge. INTCAR Cardiology is a research group nested in the main registry and comprises 6 regional centers for interventional cardiology in the United States. This group developed 56 additional data points to further evaluate the cardiovascular characteristics of the study population. The institutional review board of each institution approved data collection and participation, and INTCAR approved the registry-based project; data analysis was performed at the University of Arizona. The details of these cardiology data points were published previously (10,11) and include pre-existing cardiovascular disease, initial cardiac arrest rhythm, electrocardiographic data, left ventricular function, and coronary angiographic findings after cardiac arrest.

We collected retrospective and prospective data on 754 comatose patients who survived to hospital admission after cardiac arrest from February 2006 to May 2011. Complete outcomes data were available for 745 patients (**Figure 1**). Specific data point definitions were provided on the data extraction tool, including immediate coronary angiography being within 2 h of arrival at the PCI-capable hospital. All patient data were deidentified on entry. The study was approved by each center's institutional review board, with some approving a waiver of informed consent due to the observational nature of the study, whereas others required informed consent from survivors for any future contact.

The primary outcome was survival to hospital discharge, with a secondary outcome of functional status after discharge. Functional status post-discharge was assessed by medical records or by telephone interview and was described using the Cerebral Performance Category (CPC) score, the most commonly used post-resuscitation outcome measurement for this purpose (12). A good functional outcome was defined as a CPC score of 1 (normal) or 2 (mild or moderate functional impairment, but independent) and a poor neurological outcome as a CPC score of 3 to 5, where CPC 3 indicates conscious with severe neurological disability and dependent, CPC 4 indicates coma or vegetative state, and CPC 5 indicates dead. All patients 18 years of age or older who survived to hospitalization in a comatose state after cardiac arrest were included in the registry. Most patients included in the analysis were treated with TTM (736 of 754 [98%]) at a target core body temperature of 32°C to 34°C maintained for 24 h after return of spontaneous circulation.

For study purposes, patients were divided into 2 groups by their post-resuscitation electrocardiographic findings of STEMI or no STEMI. A culprit vessel was determined by the findings at coronary angiography, as suggested by an acute occlusion,

ABBREVIATIONS AND ACRONYMS

CAG = coronary angiography

CPC = cerebral performance category

CTO = chronic total occlusion

ECG = electrocardiogram

LAD = left anterior descending artery

LCX = left circumflex artery

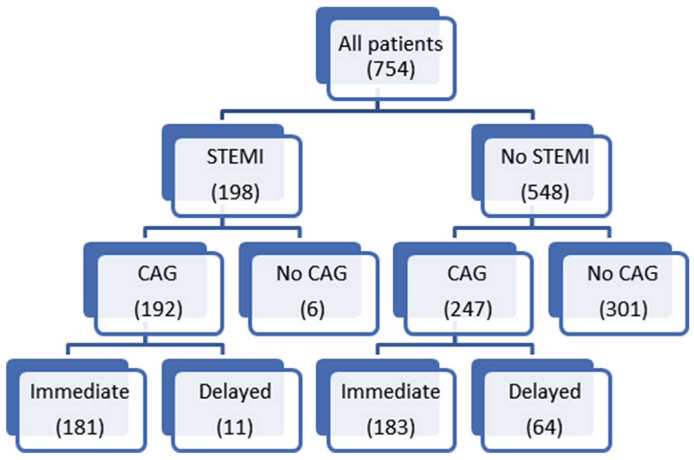
PCI = percutaneous coronary intervention

RCA = right coronary artery

STEMI = ST-segment elevation myocardial infarction

TTM = targeted temperature management

FIGURE 1 Patient Flow Diagram



CAG = coronary angiography; STEMI = ST-segment elevation myocardial infarction.

coronary thrombus, or severe, unstable-appearing lesion thought to be the likely source of an ischemic trigger of cardiac arrest. Coronary flow was assessed by the Thrombolysis In Myocardial Infarction classification. Coronary occlusions, defined as Thrombolysis In Myocardial Infarction grade 0 or 1 flow, were considered acute or recent if there was angiographic evidence of thrombus at the site of occlusion or by the ability to easily pass a guidewire through the occluded segment during intervention.

No attempt was made to dictate practice patterns regarding the selection of patients for coronary angiography; each site followed its own internal policies and protocols. All 6 centers routinely performed immediate coronary angiography for resuscitated patients presenting with STEMI. However, for patients without STEMI, the decision for immediate cardiac catheterization varied per enrolling center and sometimes within each center depending on the interventionalist. Two of the 6 participating institutions routinely performed immediate coronary angiography in all post-cardiac arrest patients regardless of STEMI findings, unless a clear noncardiac etiology was present. Two institutions did not routinely take any patients without STEMI for immediate coronary angiography, typically waiting until such patients completed TTM and the potential for neurological recovery was assessed. At the final 2 institutions, the decision to proceed with coronary angiography for patients without STEMI was varied, based on attending physician's preference, with approximately one-half of the patients undergoing immediate coronary angiography and the other one-half undergoing delayed coronary angiography after demonstrating a favorable neurological recovery.

STATISTICAL ANALYSIS. Patients surviving cardiac arrest and undergoing coronary angiography were classified into 2 groups (STEMI and no STEMI) according to their post-resuscitation ECG. The characteristics of these 2 groups were described by presenting frequencies, percentages for categorical variables, and mean ± SD for continuous variables. The Fisher exact test and 2-sample *t* tests with unequal variances were performed to compare categorical and continuous outcomes, respectively, between groups. Generalized linear mixed-effects models with a random intercept were fitted to STEMI status (yes or no) data to account for potential dependence within each center while comparing variables between those with and without STEMI. All statistical tests were 2-sided, and the significance level was set at 5%. All analyses were performed with SAS version 9.2 (SAS Institute Inc., Cary, North Carolina).

RESULTS

A total of 754 post-cardiac arrest patients (68% men; 58% with ventricular fibrillation cardiac arrest; 98% received therapeutic hypothermia) were entered into the INTCAR Cardiology 1.0 registry. The majority experienced out-of-hospital cardiac arrest (596 of 754; 79%). Postresuscitation electrocardiography found 198 patients with STEMI and 548 without STEMI. Coronary angiography was performed in 96.9% of those with STEMI and in 45.1% of those without ($p < 0.0001$). When performed, coronary angiography was accomplished immediately on hospital admission in the majority of both those with and without STEMI (94.3% vs. 74.1%) (Figure 1).

Baseline demographic and resuscitation characteristics of those with and without STEMI undergoing post-resuscitation coronary angiography are shown in Table 1. Such characteristics were generally similar; however, patients without STEMI had more chronic illnesses and a shorter time to return of spontaneous circulation, and cardiogenic shock developed less often within 2 h of presentation.

Overall survival to hospital discharge was greater for those with STEMI compared with those without (55.1% vs. 41.3%; $p = 0.001$). However, among all patients who underwent immediate coronary angiography, survival was similar for those with and without STEMI (54.7% vs. 57.9%; $p = 0.60$) (Table 2). Of note, when patients with or without STEMI did not undergo coronary angiography, their survival was equally poor (33.3% vs. 20.3%; $p = 0.61$).

Good neurological function, evaluated at 6.5 ± 4.5 months after the cardiac arrest, among survivors was similar between those with and without STEMI (88.1% vs. 89.4%; p = 0.71). Among surviving patients without STEMI, coronary angiography was associated with better functional outcomes on discharge (93.3% vs. 78.7%; p = 0.003) (Table 3). Patients with and without STEMI who underwent CAG had similar good functional status on hospital discharge (88.8% vs. 93.3%; p = 0.19) (Table 3).

The coronary angiographic findings are summarized, comparing those with and without STEMI, in Table 4. A culprit vessel was identified more often in the STEMI patients than in those without STEMI (80.2% vs. 33.2%; p < 0.001). The location of these culprit vessels was significantly different between the STEMI and no STEMI post-cardiac arrest patients. In the STEMI population, the left anterior descending artery (LAD) was the culprit artery most often, but in those without STEMI, the culprit vessel was equally distributed among the LAD, left circumflex artery (LCX), and the right coronary artery (RCA). The left main coronary was less commonly the culprit vessel among those with STEMI than in those without (3% vs. 13%; p < 0.005).

The overall incidence of culprit vessel occlusion was 84.7% (194 of 229), with 92.7% of STEMI patients having an occluded culprit vessel versus 69.2% of patients without STEMI (p < 0.001). Stent thrombosis was rarely identified as the culprit vessel (3%), and there was no significant difference in culprit vessels with stent thrombosis between those with STEMI and those without (4% vs. 1%; p = 0.53). The overall PCI rate in those with an identified culprit vessel was 88.6% (209 of 236). PCI was performed in 92.9% (143 of 154) of those with STEMI but in only 80.5% (66 of 82) of those without, even though a culprit was identified (p < 0.01).

Coronary angiography was typically performed immediately on arrival at the hospital while the majority (87.1%) of patients were still unconscious. The percentage of patients unconscious at time of PCI was higher for those with STEMI versus those without (93.7% vs. 72.7%; p < 0.001). The details of the intervention did not differ between those with and without STEMI, with equal proportions undergoing balloon angioplasty and bare-metal and drug-eluting stent placement.

TABLE 1 Baseline Characteristics for Patients Who Underwent Angiography

	STEMI (n = 192)	No STEMI (n = 247)	p Value*
Demographic data			
Age, yrs	61.3 ± 11.8	61.0 ± 13.5	0.83 (0.93)
Male	150 (78.1)	176 (71.3)	0.12 (0.12)
Chronic illness	140 (72.9)	201 (81.4)	0.04 (0.09)
Pre-cardiomyopathy	n = 191	n = 246	
HCM	0 (0.0)	2 (0.8)	0.09
NCC	0 (0.0)	1 (0.4)	N/A
IDCM	2 (1.1)	14 (5.7)	
Ischemic	33 (17.3)	50 (20.3)	
Valvular/HTN	1 (0.5)	7 (2.9)	
No cardiomyopathy	155 (81.2)	172 (69.9)	
Arrest data			
Out of hospital	164 (85.4)	199 (80.6)	0.20 (0.43)
Witness (yes)	163/191 (85.3)	213 (86.2)	0.78 (1.00)
Bystander CPR (yes)	95/190 (50.0)	134/245 (54.7)	0.34 (0.19)
Initial CA rhythm			
PEA	23 (12.0)	37 (15.0)	0.24 (0.41)
VT/VF	154 (80.2)	174 (70.5)	
Asystole	14 (7.3)	25 (10.1)	
Unknown	1 (0.5)	11 (4.5)	
Time to ROSC	24.5 ± 16.2 (n = 182)	20.7 ± 14.6 (n = 222)	0.02 (0.02)
Hospital data			
GCS score (>3)	31/160 (19.4)	56/198 (28.3)	0.06 (0.13)
Shock (yes)	83/191 (43.5)	64/245 (26.1)	<0.0001 (0.0001)
Therapeutic hypothermia (Yes)	186 (96.9)	239 (96.8)	1.00 (0.21)
Time to TH	158.6 ± 121.0 (n = 181)	177.3 ± 146.9 (n = 224)	0.16 (0.68)
DC echo	n = 186	n = 238	
Normal (EF >50%)	56 (30.1%)	88 (37.0%)	0.11 (0.07)
Mild-moderate dysfx (EF = 30%–49%)	48 (25.8)	43 (18.1)	
Severe dysfx (EF <30%)	26 (14.0)	35 (14.7)	
Echo not done	56 (30.1)	72 (30.3)	
STEMI location	n = 174	n = 96	
Anterior	78 (44.8)	N/A	
Inferior	72 (41.4)	N/A	
LBBB	12 (6.9)	N/A	
Lateral	9 (5.2)	N/A	
Posterior	1 (0.6)	N/A	
N/A	2 (1.2)	N/A	

Values are mean ± SD, n (%), or n/N (%). *The p values are reported as both unadjusted and adjusted to account for potential dependence within each center (adjusted p value in parentheses).

CA = cardiac arrest; CPR = cardiopulmonary resuscitation; DC = discharge; dysfx = dysfunction; Echo = echocardiography; EF = ejection fraction; GCS = Glasgow Coma Scale; HCM = hypertrophic cardiomyopathy; HTN = hypertension; IDCM = idiopathic dilated cardiomyopathy; LBBB = left bundle branch block; N/A = not available; NCC = noncompaction cardiomyopathy; PEA = pulseless electrical activity; ROSC = return of spontaneous circulation; VT/VF = ventricular tachycardia/ventricular fibrillation.

DISCUSSION

Post-resuscitation care, including TTM and early CAG, has become a new target for improving long-term outcomes of cardiac arrest. TTM involves cooling to a core temperature of 33°C to 36°C for 12 to 24 h. A decade ago, 2 randomized clinical studies in out-of-hospital ventricular fibrillation cardiac arrest found that TTM increased both survival and subsequent rates of good functional status among survivors (13,14). In 2003, the American Heart Association and the International Liaison Committee for Resuscitation published a joint statement supporting the use of

TABLE 2 Survival to Hospital Discharge

	STEMI	No STEMI	p Value*
All patients	55.1 (109/198)	41.3 (226/547)	0.001 (0.007)
Patients with CAG	55.7 (107/192)	66.8 (165/247)	0.02 (0.01)
Patients with immediate CAG	54.5 (99/181)	57.9 (106/183)	0.60 (0.36)
Patients with delayed CAG	72.7 (8/11)	92.2 (59/64)	0.09 (0.07)
Patients without CAG	33.3 (2/6)	20.3 (61/300)	0.61 (0.44)

Values are % (n/N). *The p values are reported as both unadjusted and adjusted to account for potential dependence within each center (adjusted values in parentheses).

CAG = coronary angiography; STEMI = ST-segment elevation myocardial infarction.

mild therapeutic hypothermia in all comatose survivors of out-of-hospital ventricular fibrillation cardiac arrest (15). This past year an additional randomized trial found excellent outcomes with TTM goals of both 33°C and 36°C (16). Temperature management for patients remaining unresponsive or comatose post-resuscitation is the first treatment proven effective at improving the functional outcomes after resuscitation from cardiac arrest.

Our data suggest the combination of TTM and early CAG is beneficial for post-cardiac arrest patients with and without STEMI.

The majority of cardiac arrest survivors undergoing angiography had a culprit lesion identified, most often the LAD or RCA. Of patients with STEMI, 80.2% demonstrated a culprit lesion compared with 33.2% of those without STEMI. These culprit vessels were usually total occlusions, including 92.7% of those with STEMI and 69.2% of those without, most of which were acute. These findings suggest an important role for urgent coronary angiography and revascularization in patients successfully resuscitated from cardiac arrest, including patients without STEMI, in whom nearly 1 in 4 had an acutely occluded epicardial coronary presumed to be the trigger of their arrest. Where a culprit vessel was found, percutaneous revascularization could be performed in 89% of cases (209 of 236). Of those undergoing PCI in this series, 78% (163 of 236) underwent it immediately on arrival at the PCI-capable facility.

OUTCOMES. Survival to hospital discharge was greater among patients with STEMI compared with those without. It is unlikely that cardiac arrest patients with STEMI have an inherently better prognosis than those without STEMI. More likely, those with STEMI were treated differently. The use of immediate coronary angiography was significantly greater in those with STEMI than in those without (96.9% vs. 45.1%; $p < 0.0001$). Evaluating all patients undergoing immediate coronary angiography post-cardiac arrest showed survival similar to hospital discharge among those with and without STEMI (54.7% vs. 57.9%; $p = 0.60$). If treated equally with early coronary angiography, survival and functional status are similar for those with and without STEMI post-cardiac arrest.

Coronary angiography is associated with better clinical outcomes in those without STEMI (**Figures 2A and 2B**).

A recent meta-analysis found similar outcome advantages for immediate coronary angiography in post-cardiac arrest patients, including those stratified for STEMI and those not so stratified (17). The authors noted a significant potential patient selection bias inherent in the available studies, resulting in a low level of evidence.

Table 2 highlights some of the shortcomings of registry data. Survival comparisons in our database suggest that delayed coronary angiography is associated with better survival than immediate angiography. Pondering such results suggests inherent bias. Delayed coronary angiography can only be performed in those who survive the first few days in the hospital. Those who die before hospital day 3 or 4, the typical time for performing delayed angiography, are not included when comparing early with delayed catheterization outcomes. Also, delayed coronary angiography is unlikely to be performed in patients thought to be neurologically moribund. This example highlights the importance of other supporting data to substantiate and add credibility to outcome results from nonrandomized registries. The angiographic findings in this report support and strengthen the outcome findings. Specifically, the percentage of both patient groups having an identifiable culprit vessel is substantial. Patients without STEMI have fewer culprit vessels identified than those with STEMI (33.2% vs. 80.2%); nonetheless, a culprit is found in at least 1 of every 3 patients without STEMI undergoing angiography. The majority of such culprit vessels are occluded in both those with and without STEMI (92.7% vs. 69.2%). Combining these data

TABLE 3 Good Neurological Function Among Survivors (CPC 1 or 2)

	STEMI	No STEMI	p Value
All patients	88.1 (96/109)	89.4 (202/226)	0.71 (0.64)
Patients with CAG	88.8 (95/107)	93.3 (155/165)	0.26 (0.20)
Patients with immediate CAG	88.9 (88/99)	92.5 (98/106)	0.47 (0.45)
Patients with delayed CAG	87.5 (7/8)	94.9 (59/59)	0.41 (0.43)
Patients without CAG	50.0 (1/2)	78.7 (48/61)	0.40 (0.35)

Values are % (n/N). The p values are reported as both unadjusted and adjusted to account for potential dependence in each center (adjusted values in parentheses).

CPC = cerebral performance category; other abbreviations as in **Tables 1 and 2**.

suggests that 1 in 4 patients without STEMI has an occluded culprit vessel requiring timely reperfusion to preserve myocardium and thereby long-term outcome.

POST-ARREST CORONARY ANGIOGRAPHIC FINDINGS. Our angiographic findings are similar to those of 2 previous but smaller cohort reports. Radsel et al. (18) reported the angiographic findings of 158 cardiac arrest survivors with STEMI and 54 without STEMI. They found 89% of those with cardiac arrest and STEMI had an identifiable culprit compared with 24% of those without STEMI. The culprit vessels in those with STEMI were similar to our findings.

Zanuttini et al. (19) reported coronary anatomy in a series of 91 cardiac arrest patients, including 40 with STEMI and 51 without STEMI post-cardiac resuscitation. These authors found that 86% of their patients had significant coronary disease, more commonly seen in those with STEMI (98%) than in those without (77%). An identifiable culprit vessel was found in 56% of patients, including 85% in those with STEMI and 33% in those without STEMI.

CULPRIT VESSELS AFTER RESUSCITATION FROM CARDIAC ARREST. The LCX was less frequently found to be the culprit vessel than either the LAD or RCA. This is similar to reports of acute STEMI patients without cardiac arrest (20,21). In the noncardiac arrest STEMI literature, clinical outcomes are worse with LAD and RCA culprits, whereas in this cardiac arrest registry, the clinical outcomes were not different according to culprit vessel location, presumably because in this population, prognosis is more affected by the cardiac arrest than which vessel was the ischemic trigger. The percentage of cardiac arrest STEMI patients with an identified LCX culprit vessel is smaller, most likely attributable to the electrically silent zone in the LCX distribution. The situation was different for cardiac arrest patients without STEMI. In this population, the identified culprit vessels were equally distributed among the 3 main epicardial coronaries (LAD, LCX, and RCA). This experience is similar to acute coronary syndrome/no STEMI patients without cardiac arrest (22).

Stent thrombosis was identified as the culprit lesion in 3% of our patients. This is lower than the 6% to 11% incidence reported in the noncardiac arrest STEMI population (23). It is possible that stent thrombosis resulting in cardiac arrest is more difficult to resuscitate, and such patients are not surviving to undergo coronary angiography. There were only 7 patients with stent thrombosis in our dataset, but the vessel involvement was similar, with 3 involving the RCA, 2 the LCX, and 2 the LAD.

TABLE 4 **Coronary Angiographic and Intervention Findings**

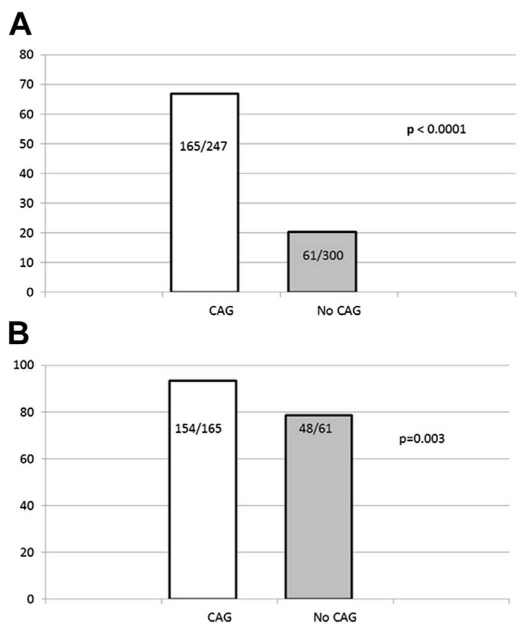
	STEMI (n = 192)	No STEMI (n = 247)	p Value
Angiographic data			
Culprit (yes)	154 (80.2)	82 (33.2)	<0.0001 (<0.0001)
Location	n = 154	n = 82	
LM	4 (2.6)	11 (13.4)	<0.0001 (<0.0001)
LAD	80 (52.0)	25 (30.5)	
LCX	20 (13.0)	22 (26.8)	
RCA	50 (32.5)	24 (29.3)	
Culprit occluded (yes)	140/151 (92.7)	54/78 (69.2)	<0.0001 (0.0001)
Percentage of stenosis if not occluded	88.2 ± 11.2 (n = 10)	88.6 ± 11.2 (n = 23)	0.92 (0.92)
CAD data	(n = 154)	(n = 82)	
Percentage of stenosis of culprit vessel			
LM	79.8 ± 15.9 (n = 4)	75.5 ± 13.2 (n = 8)	0.66 (0.61)
LAD	97.1 ± 6.9 (n = 77)	92.9 ± 8.9 (n = 25)	0.04 (0.03)
LCX	98.9 ± 2.0 (n = 20)	92.8 ± 8.6 (n = 22)	<0.01 (0.03)
RCA	97.9 ± 5.6 (n = 48)	92.3 ± 9.6 (n = 22)	0.02 (0.01)
Chronic total occlusions (yes)	38/149 (25.5)	20/79 (25.3)	1.00 (0.86)
Stent thrombosis (yes)	6/154 (3.9)	1/82 (1.2)	0.53 (0.49)
Intervention data			
PCI performed (yes)	143/154 (92.9)	66/82 (80.5)	<0.01 (0.01)
Pts conscious at PCI (yes)	9/143 (6.3)	18/66 (27.3)	<0.0001 (<0.0001)
PCI type	n = 143	n = 66	
POBA	34 (23.4)	20 (30.3)	0.31 (0.58)
BMS	68 (47.6)	28 (42.4)	0.55 (0.53)
DES	69 (48.3)	34 (51.5)	0.77 (0.49)
Thrombus aspiration	33 (23.1)	6 (9.1)	0.02 (0.01)
Time from ED door to balloon	63.4 ± 25.6 (n = 99)	72.9 ± 21.9 (n =0)	0.07 (0.31)
Time from ROSC to reperfusion >120 min	30/85 (35.3)	16/25 (64.0)	0.02 (0.01)
Arrest due to acute coronary occlusion	124/154 (80.5)	43/82 (52.4)	<0.0001 (<0.0001)
PCI complications	(n = 143)	(n = 66)	
Unable to cross (yes)	5 (3.5)	3 (4.6)	0.71 (0.66)
Dissection (yes)	2 (1.4)	2 (3.0)	0.59 (0.43)
No reflow (yes)	8 (5.6)	2 (3.0)	0.51 (0.46)
Perforation (yes)	0 (0.0)	0 (0.0)	1.00 (1.00)
Rearrest during PCI (yes)	14 (9.8)	1 (1.5)	0.04 (<0.05)
Death in cath lab (yes)	1 (0.7)	0 (0.0)	1.00 (N/A)

Values are n (%), n/N (%), or mean ± SD. The p values are reported as both unadjusted and adjusted to account for potential dependence within each center (adjusted values in parentheses).

BMS = bare metal stent; CAD = coronary artery disease; DES = drug-eluting stent; ED = emergency department; LAD = left anterior descending artery; LCX = left circumflex artery; LM = left main artery; PCI = percutaneous coronary intervention; POBA = plain old balloon angioplasty; RCA = right coronary artery; other abbreviations as in Tables 1 and 2.

Approximately one-fourth of the cardiac arrest patients in both groups had at least 1 chronic total occlusion (CTO). In this registry experience, these CTOs were defined by the failure of standard intracoronary wires to cross the occlusion. Once identified, CTOs were considered nonculprits and no PCI was

FIGURE 2 Survival to Discharge and Favorable Neurological Outcome in Those Without ST Elevation



Coronary angiography is associated with improved survival to hospital discharge among patients without ST-segment elevation myocardial infarction **(A)** and with good neurological function (cerebral performance category 1 or 2) among survivors without ST-segment elevation myocardial infarction **(B)**. CAG = coronary angiography.

attempted. Currently, it is not known whether these CTOs are just bystanders or whether they are contributing to the overall ischemic burden in these patients. If the latter is true, it could alter our approach to CTO in this post-cardiac arrest population. These CTOs could be considered for revascularization, particularly given the new interventional tools that have greatly improved the rate of successful recanalization of such CTOs. Similarly, the new concept of preventive PCI, that is, complete percutaneous revascularization rather than treating only the culprit vessel for those with STEMI (24), seems particularly germane for those with cardiac arrest and STEMI. The sickest patients seem to be the ones most likely to benefit from such a strategy, and few patients are sicker than the post-resuscitated patient. A nonrandomized cohort report of this strategy was recently shown to be associated with better outcomes in those with STEMI, cardiac arrest, and cardiogenic shock who were initially treated with full revascularization rather than just culprit vessel reperfusion (25). Our series did not evaluate either of these approaches, but future investigations should do so.

CULPRIT VESSEL ANATOMY AND PCI. The severity of the coronary artery culprit found at emergent coronary angiography, measured by the mean percentage of stenosis, differed between those resuscitated from cardiac arrest with and without STEMI. Left main coronary disease was more common in those without STEMI (3% vs. 13%), whereas other coronary culprits were more severe in those with STEMI (Table 4).

PCI was performed in 89% of all those with an identifiable culprit vessel. It cannot be determined from our database exactly why the other 11% did not undergo PCI. It was more common for patients with STEMI and cardiac arrest to undergo PCI (93%) versus those without STEMI (80%; $p < 0.01$). The culprit vessel mean percentage of stenosis in those undergoing PCI in the STEMI patients was 97 ± 7% versus 92 ± 9% ($p < 0.0001$) in those patients without STEMI.

IMPLICATIONS. Previous reports of improved outcomes with immediate coronary angiography among post-cardiac arrest patients with STEMI have drawn attention to the need to remove such patients from publicly reported institutional mortality results. In 2013, the American Heart Association published a scientific statement titled “Impact of Percutaneous Coronary Intervention Performance Reporting on Cardiac Resuscitation Centers,” highlighting the 10-fold difference in expected mortality between patients with STEMI and patients with STEMI associated with cardiac arrest. They concluded “that out-of-hospital cardiac arrest cases should be tracked but not publicly reported or used for overall PCI performance ranking that would allow accountability for their management but would not penalize high-volume cardiac resuscitation centers for following the AHA 2010 guidelines for CPR and ECC” (26).

Our data suggesting benefit from immediate coronary angiography for post-cardiac arrest patients with and without STEMI makes this issue even more important. The current reporting of post-cardiac arrest patients’ outcomes in general STEMI and PCI performance measures should be changed to avoid potential negative incentives from affecting optimal patient care.

STUDY LIMITATIONS. Resuscitated cardiac arrest patients who were responsive or awake on evaluation at the hospital were not included in this analysis because they did not require therapeutic hypothermia. If and when coronary angiography was performed was left to the discretion of the individual attending physician. Coronary findings could be influenced by the decision as to which patients were referred for immediate coronary angiography and which were not. Determination of which vessel was "culprit" is subjective; however, independent reports from Europe (18,19) corroborate our culprit coronary findings.

CONCLUSIONS

Immediate coronary angiography in cardiac arrest survivors appears to be associated with better survival to discharge and post-discharge neurological function regardless of whether the ECG manifested STEMI. Post-cardiac arrest patients with STEMI fared better than those without, but when immediate angiography was performed in both sets of patients, this difference in outcome disappeared. The documentation of an occluded culprit artery in nearly 1 in 4 patients without STEMI helps explain why early angiography in these patients can improve outcomes. Early coronary angiography provides useful information and can direct therapy, particularly identifying those who may benefit from acute coronary reperfusion therapy in those without STEMI as well as those with STEMI.

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PERSPECTIVES

WHAT IS KNOWN? The American College of Cardiology Foundation/American Heart Association 2013 STEMI Guidelines recommend performing immediate angiography in resuscitated patients whose initial ECG shows STEMI (Class I recommendation). Whether post-cardiac arrest patients without STEMI should immediately undergo angiography is less clear.

WHAT IS NEW? In the INTCAR-Cardiology database of 746 comatose post-cardiac arrest patients, we found an occluded culprit vessel in 3 or every 4 (74.3%) STEMI patients, but also in 1 of every 4 (22.9%) patients without STEMI.

WHAT IS NEXT? Early coronary angiography immediately after successful resuscitation from cardiac arrest identifies those with and without STEMI who can benefit from acute coronary reperfusion therapy.

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KEY WORDS cardiac arrest, coronary angiography, hypothermia, post-resuscitation syndrome, STEMI

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