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Factors Associated with Performing Urgent Coronary Angiography in Out-of-Hospital Cardiac Arrest Patients

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Abstract

Objectives—We sought to identify factors associated with performing urgent coronary angiography (UCA) in patients with out-of-hospital cardiac arrest (OHCA).

Background—Current guidelines for resuscitated OHCA patients recommend UCA if there is ST-elevation on post-arrest electrocardiogram or high suspicion of acute myocardial infarction. Some have advocated for UCA in all OHCA regardless of suspected etiology. The reasons for variations in performing UCA are not well understood.

Methods—We conducted a retrospective analysis of subjects presenting with resuscitated OHCA to a single academic medical center from 12/15/2007 to 8/31/2014. Demographic and clinical characteristics of patients undergoing UCA, defined as angiography within 6 hours of presentation, were compared with those not undergoing UCA. Logistic regression was used to determine predictors of UCA.

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Results—A total of 323 resuscitated OHCA patients (mean age, 64 years; women, 35%) were included in the analysis; 107 (33.1%) underwent coronary angiography during their hospitalization and 66 (20.4%) underwent UCA. Multivariable adjusted factors associated with UCA were ST-elevation (odds ratio (OR) 14.66, 95% confidence interval (CI) 6.28-34.24, $p<0.001$), initial shockable rhythm (OR 3.69, 95% CI 1.52-8.97, $p=0.004$), and history of coronary artery disease (CAD) (OR 3.37, 95% CI 1.43-7.95, $p=0.005$). Higher age (OR 0.71 per decade, 95% CI 0.55-0.92, $p=0.01$) and obvious non-cardiac cause of arrest (OR 0.08, 95% CI 0.02-0.38, $p=0.001$) were negatively associated with UCA.

Conclusions—In resuscitated out-of-hospital cardiac arrest patients, ST-elevation, shockable rhythm, and history of CAD were associated with performing urgent coronary angiography; older patients and those with obvious non-cardiac causes of arrest were negatively associated.

Keywords

Coronary angiography; Coronary artery disease; Percutaneous coronary intervention

Introduction

Out-of-hospital cardiac arrests (OHCA) are common and associated with poor outcome, occurring in 347,000 adults in the United States in 2015 with only 10.6% surviving to hospital discharge [1]. The most common etiology of OHCA in the general population involves coronary artery disease (CAD) [2], frequently due to acute coronary occlusion [3]. As such, some have advocated for routine coronary angiography in resuscitated cardiac arrest patients [4-6]. Current practice guidelines recommend urgent coronary angiography (UCA) for post-arrest patients with ST elevations on the post-arrest electrocardiogram (ECG); UCA is also reasonable in select patients after OHCA of suspected cardiac origin without ST elevations [7]. Despite this, many patients surviving cardiac arrest do not undergo coronary angiography, with reported angiography rates ranging from 27-70% [4,8-11]. When coronary angiography is routinely performed in all patients without an obvious non-cardiac cause of arrest, acute coronary lesions are present in a large proportion with the majority receiving percutaneous coronary intervention (PCI) [4]. Potential reasons for variation in angiography rates in OHCA include perceived futility, patient or family preference, high acuity of comorbid or presenting illnesses, and operator risk aversion in the era of public reporting of outcomes after PCI [12]. Understanding factors associated with UCA in OHCA within a state which utilizes public reporting of PCI outcomes may assist in understanding variation and may improve decision making among emergency medicine physicians, intensivists, and cardiologists. As such, we performed a retrospective analysis of OHCA patients surviving to hospital admission at a single academic medical center to identify factors associated with receipt of UCA.

Materials and Methods

Study Design

We performed a retrospective analysis identifying consecutive cardiac arrest patients who achieved return of spontaneous circulation (ROSC) and were admitted to Beth Israel

Deaconess Medical Center (BIDMC), a large tertiary academic hospital in Boston, Massachusetts, USA from December 15, 2007 to August 31, 2014. Patients were excluded from the analysis if there was in-hospital cardiac arrest, treatment with UCA at an acute care hospital prior to transfer to BIDMC, or incomplete medical records. Demographic data (age, sex, and primary language) and study variables were abstracted from the hospital's electronic and scanned medical records by two physicians (D.H.L., L.M.G.). Race and socioeconomic data were missing from the records. The study was approved under exempt status by the BIDMC Institutional Review Board.

Study Variables and Outcomes

Comorbid variables, including history of coronary artery disease, prior cerebrovascular accident (CVA), and presence of dementia, were obtained from review of hospital documentation. Patient and arrest characteristics included presence of an initial shockable rhythm, presentation with ST-elevation on ECG, obvious non-cardiac cause for the arrest, ability to follow commands after ROSC, hypotension, contraindication to anticoagulation, presence of a do-not-resuscitate (DNR) order prior to admission, presentation from a nursing home or rehabilitation center, and presentation during daytime hours. Laboratory and ECG data were reviewed to adjudicate arrest characteristics. Initial shockable rhythm was defined as chart or ECG evidence of ventricular fibrillation, pulseless ventricular tachycardia, or shock advised by an automated external defibrillator during the initial arrest. If an obvious non-cardiac cause of arrest was readily identified or presumed by initial providers, this was noted, such as antecedent respiratory failure, trauma, or drug overdose. Hypotension was defined as systolic blood pressure of less than 90 mmHg on presentation, or vasopressor administered either in the emergency department or within six hours of the first phlebotomy. Contraindications to anticoagulation were defined as intracranial bleeding on cerebral imaging, clinical evidence of severe active bleeding, platelets less than 50,000 per uL, or hemoglobin less than 7 mg/dL. Daytime hours were defined as Monday to Friday from 8:00 AM to 5:00 PM, determined by time of first phlebotomy. ST-elevation was defined as 1 mm or more ST-elevation in two or more contiguous limb or precordial leads. Presence of bystander cardiopulmonary resuscitation (CPR), time until ROSC, and Glasgow Coma Scale (GCS) scores were frequently missing from charting and were excluded from analysis. Coronary angiograms and reports were reviewed by two physicians (D.H.L., L.M.G.) and angiographic and procedural data abstracted including presence of 70% or greater stenosis in at least one coronary artery and post-arrest revascularization with PCI or coronary artery bypass grafting (CABG).

The primary outcome was receipt of UCA, defined as coronary angiography within 6 hours of presentation. Myocardial infarction was defined as a troponin-T of greater than or equal to 0.10 ng/mL at any time during the hospitalization, corresponding to the 99th percentile for the upper limit of normal in the BIDMC laboratory. Myocardial infarctions were classified by reviewers as Type 1 ST-elevation myocardial infarction (STEMI), Type 1 non-ST elevation myocardial infarction (NSTEMI) or other, according to the Third Universal Definition of Myocardial Infarction [13]. In-hospital mortality was adjudicated and stratified by etiology into cardiac cause, neurologic cause, withdrawal of care due to cardiac cause, withdrawal of care due to neurologic cause, or other.

Statistical Analysis

Patients undergoing UCA were compared with patients who did not undergo UCA using the Student t-test for age and Chi-square tests or Fisher exact tests for categorical variables. Univariable odds ratios (OR) of UCA were determined for all collected variables using logistic regression. Subsequent multivariable analysis was performed using logistic regression to determine likelihood of UCA, using stepwise forward selection, forcing age and gender into the model, with a criterion for entry of $p < 0.05$ and to remain of $p < 0.05$. Pre-specified secondary analyses were performed comparing unadjusted rates of myocardial infarction, in-hospital mortality, and cardiac death between those undergoing UCA versus those who did not using Chi-Square tests in those with and without an obvious non-cardiac etiology for arrest. A sensitivity analysis was performed excluding those individuals with prior do-not-resuscitate (DNR) orders. Analyses were conducted using SAS version 9.3 (SAS Institute Inc., Cary, NC) using a threshold for significance of $\alpha < 0.05$.

Results

A total of 323 patients were included in the analysis (mean age, 64 years $\pm$ 17.7; 35% female) (Figure 1). Of these, 66 (20%) underwent UCA (Table 1). An additional 41 patients (13%) underwent coronary angiography during their hospitalization after the initial 6 hours. Individuals receiving UCA were more frequently male, had a prior history of CAD, were more likely to present from a nursing home or rehabilitation facility, have an initial shockable rhythm, present with ST-elevation on ECG, be able to follow commands post-ROSC, and were less likely to have a non-cardiac etiology presumed for the cardiac arrest (Table 2). Out of 55 patients in the overall cohort with ST-elevation on ECG (17%), 39 (71%) underwent UCA.

Unadjusted rates of myocardial infarction were higher among those who proceeded to UCA compared to those who did not (86% vs 67%, $p = 0.0016$). Among patients who suffered any myocardial infarction, most among the UCA cohort had type 1 STEMI or NSTEMI while most among the non-UCA cohort had non-type 1 myocardial infarctions (Figure 2).

Among the 66 patients taken for UCA, a 70% or greater stenosis was found on coronary angiography in 54 (82%), and of those, most received either PCI (37 [69%]) or CABG (3 [6%]). Most STEMI patients received PCI (28 [76%]). In the 26 patients who underwent UCA who did not undergo revascularization, 13 (50%) had a coronary stenosis $\leq 50\%$, 6 (23%) had a stenosis $> 60\%$ deemed to be a non-culprit lesion, and 6 (23.1%) had chronic total occlusions. One patient was found to have severe 3-vessel CAD and was referred for CABG but had care transitioned to comfort measures due to anoxic brain injury.

Culprit vessels were identified by the usual practice of our interventional cardiologists which involved review of the coronary angiography and identifying the presence of thrombus, ulcerated lesions, etc. It was not standard practice in our cardiac catheterization laboratory at the time of this analysis to perform non-infarct related artery PCI. Recent trials suggesting benefit for PCI of non-infarct related arteries in STEMI patients such as PRAMI [14] and DANAMI-3--PRIMULTI [15] excluded shock patients. The strategy of multivessel PCI in

shock patients remains debated. Among our cohort of patients who underwent UCA, 4 received multi-vessel PCI and 3 of them presented with shock.

Overall, 174 patients with resuscitated OHCA (54%) died during the hospitalization. The majority of deaths were attributed to neurologic causes or withdrawal of care due to neurologic injury (Figure 3). Crude rates of in-hospital mortality were lower among those who underwent UCA (33% vs 60%, $p=0.0001$). Rates of cardiac death were similar among those receiving UCA vs. those who did not (9% vs 14%, $p=0.55$). Among all patients, obvious non-cardiac etiologies for arrest were present in 138 (41%), most frequently due to respiratory failure, overdose, hemorrhage, metabolic derangements, or sepsis (Figure 4). Patients with an obvious non-cardiac causes of arrest were less likely to suffer myocardial infarction during their hospitalization (55% vs 82%, $p<0.0001$) but had a higher unadjusted in-hospital mortality (67% vs 45%, $p<0.0001$). Among those with non-cardiac etiologies of arrest, rates of cardiac death were similar regardless of receiving UCA or not (16% vs 10%, $p=0.20$). Those with an obvious non-cardiac cause of arrest were much less likely to proceed to UCA (1% vs 35%, $p<0.0001$).

After multivariable adjustment (Table 3), factors significantly associated with performing UCA were ST-elevation on ECG (OR 14.66, 95% confidence interval (CI) 6.28-34.24, $p<0.001$), initial shockable rhythm (OR 3.69, 95% CI 1.52-8.97, $p=0.004$), and history of CAD (OR 3.37, 95% CI 1.43-7.95, $p=0.005$). Higher age (OR 0.71 per decade, 95% CI 0.55-0.92, $p=0.01$) and obvious non-cardiac cause of arrest (OR 0.08, 95% CI 0.02-0.38, $p=0.001$) were inversely associated with receipt of UCA. All 7 patients with DNR orders prior to admission were not taken to UCA. A sensitivity analysis was performed excluding patients with prior DNR orders and showed no change in effect estimates. Our initial data collection defined significant ST-elevations as 1 mm ST elevations in two or more contiguous leads. Post-analysis reclassification of ST-elevation to include 2 mm elevations for leads V2 and V3 identified only one patient who no longer met the original criteria.

There were two patients with an obvious non-coronary cause of arrest who proceeded with UCA. One had ventricular fibrillation felt to be related to hypotension in setting of prior scar but ischemia was suspected. The other had septic shock as the primary cause for arrest accompanied by ST-elevation on ECG and was found to have significant left main disease on angiography. Conversely, despite ST-elevation on ECG, 16 patients did not proceed to UCA; 3 of them ultimately underwent coronary angiography during the hospitalization but after the initial 6 hours. The majority of reasons for not proceeding with UCA were because the initial providers had already determined the cause of arrest was not acute coronary syndrome and/or UCA was not deemed clinically indicated or beneficial due to patient and clinical factors. Reasons included pulmonary emboli (2), scar-related monomorphic ventricular tachycardia with aneurysm causing ST-elevation (4), contraindication to anticoagulation (2) with severe bleeding (massive gastrointestinal bleeding, intracranial hemorrhage), suspected vasospasm with reversible ST changes (2), profound hemodynamic derangement requiring extracorporeal membrane oxygenation for stabilization and death before UCA (1) or a cardiac arrest combined with competing life threatening or complicating illness such as advanced dementia, drug overdose, respiratory failure, and/or withdrawal of care by healthcare proxy prior to UCA (5).

Discussion

OHCA is associated with substantial in-hospital mortality. Given the procedural and therapeutic risks of UCA as well as uncertainty regarding benefit in some of these patients, identifying predictors of the decision to UCA may inform clinical decision making and policy in this critically ill population. This analysis adds to our current knowledge by investigating the effect of specific clinical and nonclinical factors associated with the decision to proceed to urgent coronary angiography after OHCA.

Our study identified three main characteristics significantly associated with the decision to proceed with coronary angiography within six hours of presentation after OHCA: presentation with ST-elevation on ECG, an initial shockable rhythm, and a history of coronary artery disease. Initial shockable rhythm and history of CAD are suggestive of a higher pre-test probability of having an underlying acute coronary syndrome leading to cardiac arrest [16], and predicted a higher rate of UCA in our study. Prior studies have suggested that male gender, transfer from an outside hospital, presentation with ST-elevation, and new left bundle branch block were associated with UCA whereas presence of an initial non-shockable rhythm (pulseless electrical activity or asystole) and low GCS scores were inversely associated with UCA [10]. In our study, we examined additional nonclinical factors which have been shown to affect clinical care such as language [17] and non-daytime hours [18]. We did not find any association for patients presenting from nursing homes or rehabilitation facilities, having a non-English primary language, or presenting during daytime hours versus non-daytime hours on odds of receiving UCA.

Guideline recommendations suggest UCA in the setting of ST-elevation on the post-arrest ECG. Despite these recommendations, only 71% of patients with STEMI in this cohort underwent UCA, similar to an analysis of UCA among cardiac arrest survivors with STEMI [19]. We found numerous conditions suggestive of futility or that a new thrombotic occlusion of a coronary vessel was not the etiology of OHCA among patients with ST-elevation who did not undergo UCA. As such, appropriate use of UCA may not be 100% in this population.

There is increasing debate about whether patients presenting without STEMI should undergo UCA after cardiac arrest. In one study, the majority of patients without ST-elevation did not have a culprit vessel identified (66%), though UCA was associated with improved survival [6]. It is feasible that perhaps those who received coronary angiography were also more likely to receive other cardiac arrest interventions such as targeted temperature management, aggressive resuscitation, treatment of shock and sepsis, etc, that improve survival independently of coronary angiography. We identified an obvious non-cardiac cause for arrest in over 40% of cases. An obvious non-cardiac cause for arrest was negatively correlated with performance of UCA in the multivariable model. Of those who underwent UCA, most had significant coronary stenosis on angiography (82%) and a majority (74%) were revascularized. Most of the myocardial infarctions documented in those not taken to UCA were attributed to demand-supply mismatch (i.e. Type 2 Myocardial Infarction). Those not taken for UCA had higher in-hospital mortality, which may suggest a benefit from UCA or confounding by severity of illness. Together, these findings suggest that physicians can

identify a group of patients with high pre-test probability of CAD and that this type of evaluation is critically important in the group of patients with non-cardiac causes for arrest.

Though the presence of CAD is common on coronary angiography after OHCA regardless of the suspected etiology for arrest and PCI in this context has been associated with improved outcomes, whether or not the presence of CAD and revascularization is a causal correlate with survival or not is difficult to determine. In an analysis of the PROCAT (Parisian Region Out of hospital Cardiac Arrest) registry, 70% of patients with non-cardiac causes of arrest had at least one significant coronary artery lesion identified [4]. In the same study, successful coronary angioplasty was an independent predictor of survival. In a similar study, only 27% of patients with adjudicated cardiac etiologies for arrest had normal angiograms, 14% had non-significant coronary stenosis, and 59% had one or more significant stenosis [8]. In another study of post-cardiac arrest patients, an occluded culprit vessel was found in 74.3% of patients with ST-elevation [6].

There are a myriad of comorbid conditions and contraindications to UCA and revascularization. Given these and the complicating issues of futility, better risk stratification and assessment is necessary to differentiate OCHA patients without ST-elevation on ECG who are likely to benefit from revascularization from those who undergo UCA without any therapeutic intervention. Furthermore, before UCA is recommended as part of standardized post-resuscitation care for OHCA patients, UCA accompanied by revascularization should be shown to improve survival in a condition where neurologic death predominates. In our study, those undergoing PCI more frequently died of neurologic causes rather than as complications of the PCI, consistent with prior studies [20]. These results have implications for use of mortality as a publicly reportable performance measure after PCI. Among patients with acute myocardial infarction and concomitant cardiac arrest, hospitals in public reporting states such as ours are significantly less likely to perform percutaneous revascularization than those in non-publicly reported states [21]. Patients with acute myocardial infarction in public reporting states also have higher adjusted in-hospital mortality rates, especially those who did not receive PCI. As such, it is plausible that concerns about public reporting of PCI outcomes could affect cardiologists' decisions to perform UCA in post-arrest patients, since these patients have a significantly higher risk of mortality than non-arrest patients with acute coronary syndrome.

The retrospective nature of this study precludes causal inference. In a retrospective analysis, we cannot address unmeasured confounding. Additionally, given the analysis was done at a single center, the results may not be generalizable to other sites. Moreover, certain covariates were limited by availability in the electronic medical record. For example, primary language is based on the language listed in the medical record and non-English speaking patients who arrive comatose may not have been identified. Other factors such as pre-existing DNR code status prior to admission were not always documented or known to medical providers. Finally, the decision to proceed with UCA is made by an interventional cardiologist whose individual preferences and decision-making may not be readily discernible through chart review.

Conclusion

Among patients who achieved ROSC after OHCA, patients with ST-elevation on ECG, shockable rhythm, or history of CAD were more likely to receive coronary angiography within six hours of presentation; older patients and those with an obvious non-cardiac cause of arrest were less likely to undergo angiography. Patients who proceeded to urgent coronary angiography had higher unadjusted rates of myocardial infarction and lower in-hospital mortality. Many of them were found to have spontaneous myocardial infarction, significant coronary stenosis, and received intervention. Patients with an obvious non-cardiac cause of arrest were less likely to suffer myocardial infarction but had higher in-hospital mortality, mostly from non-cardiac causes. Identifying individuals who will derive meaningful benefit from coronary angiography and revascularization in the post-cardiac arrest setting remains a challenge and further studies are needed.

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References

1. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, Das SR, de Ferranti S, Després JP, Fullerton HJ, Howard VJ, Huffman MD, Isasi CR, Jiménez MC, Judd SE, Kissela BM, Lichtman JH, Lisabeth LD, Liu S, Mackey RH, Magid DJ, McGuire DK, Mohler ER 3rd, Moy CS, Muntner P, Mussolino ME, Nasir K, Neumar RW, Nichol G, Palaniappan L, Pandey DK, Reeves MJ, Rodriguez CJ, Rosamond W, Sorlie PD, Stein J, Towfighi A, Turan TN, Virani SS, Woo D, Yeh RW, Turner MB. American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics-2016 Update: A Report From the American Heart Association. *Circulation*. 2016; 133(4):e38–e360. [PubMed: 26673558]
2. Zheng ZJ, Croft JB, Giles WH, Mensah GA. Sudden cardiac death in the United States, 1989 to 1998. *Circulation*. 2001; 104(18):2158–63. [PubMed: 11684624]
3. Spaulding CM, Joly LM, Rosenberg A, Monchi M, Weber SN, Dhainaut JF, Carli P. Immediate coronary angiography in survivors of out-of-hospital cardiac arrest. *N Engl J Med*. 1997; 226:1629–33.
4. Dumas F, Cariou A, Manzo-Silberman S, Grimaldi D, Vivien B, Rosencher J, Empana JP, Carli P, Mira JP, Jouven X, Spaulding C. Immediate percutaneous coronary intervention is associated with better survival after out-of-hospital cardiac arrest: insights from the PROCAT (Parisian Region Out of hospital Cardiac Arrest) registry. *Circ Cardiovasc Interv*. 2010; 3:200–7. [PubMed: 20484098]
5. Camuglia AC, Randhawa VK, Lavi S, Walters DL. Cardiac catheterization is associated with superior outcomes for survivors of out of hospital cardiac arrest: Review and meta-analysis. *Resuscitation*. 2014; 85:1533–40. [PubMed: 25195073]
6. Kern KB, Lotun K, Patel N, Mooney MR, Hollenbeck RD, McPherson JA, McMullan PW, Unger B, Hsu CH, Seder DB. INTCAR-Cardiology Registry. Outcomes of Comatose Cardiac Arrest Survivors With and Without ST-Segment Elevation Myocardial Infarction: Importance of Coronary Angiography. *JACC Cardiovasc Interv*. 2015; 8:1031–40. [PubMed: 26117462]
7. Callaway CW, Donnino MW, Fink EL, Geocadin RG, Golan E, Kern KB, Leary M, Meurer WJ, Peberdy MA, Thompson TM, Zimmerman JL. Part 8: Post-Cardiac Arrest Care: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015; 132(18 Suppl 2):S465–82. [PubMed: 26472996]

8. Sideris G, Voicu S, Dillinger JG, Stratiev V, Logeart D, Broche C, Vivien B, Brun PY, Deye N, Capan D, Aout M, Megarbane B, Baud FJ, Henry P. Value of post-resuscitation electrocardiogram in the diagnosis of acute myocardial infarction in out-of-hospital cardiac arrest patients. *Resuscitation*. 2011; 82:1148–53. [PubMed: 21632166]
9. Casella G, Carinci V, Cavallo P, Guastaroba P, Pavesi PC, Pallotti MG, Sangiorgio P, Barbato G, Coniglio C, Iarussi B, Gordini G, Di Pasquale G. Combining therapeutic hypothermia and emergent coronary angiography in out-of-hospital cardiac arrest survivors: Optimal post-arrest care for the best patient. *Eur Heart J Acute Cardiovasc Care*. 2015; 4:579–88. [PubMed: 25522746]
10. Reynolds JC, Callaway CW, El Khoudary SR, Moore CG, Alvarez RJ, Rittenberger JC. Coronary angiography predicts improved outcome following cardiac arrest: propensity-adjusted analysis. *J Intensive Care Med*. 2009; 24:179–86. [PubMed: 19321536]
11. Reynolds JC, Rittenberger JC, Toma C, Callaway CW. Post Cardiac Arrest Service. Risk-adjusted outcome prediction with initial post-cardiac arrest illness severity: implications for cardiac arrest survivors being considered for early invasive strategy. *Resuscitation*. 2014; 85:1232–9. [PubMed: 24927928]
12. McCabe JM, Joynt KE, Welt FG, Resnic FS. Impact of public reporting and outlier status identification on percutaneous coronary intervention case selection in Massachusetts. *JACC Cardiovasc Interv*. 2013; 6:625–30. [PubMed: 23787236]
13. Thygesen K, Alpert JS, Jaffe AS, Simoons ML, Chaitman BR, White HD, Joint ESC/ACCF/AHA/WHF Task Force for the Universal Definition of Myocardial Infarction. Katus HA, Lindahl B, Morrow DA, Clemmensen PM, Johanson P, Hod H, Underwood R, Bax JJ, Bonow RO, Pinto F, Gibbons RJ, Fox KA, Atar D, Newby LK, Galvani M, Hamm CW, Uretsky BF, Steg PG, Wijns W, Bassand JP, Menasché P, Ravkilde J, Ohman EM, Antman EM, Wallentin LC, Armstrong PW, Simoons ML, Januzzi JL, Nieminen MS, Gheorghiade M, Filippatos G, Luepker RV, Fortmann SP, Rosamond WD, Levy D, Wood D, Smith SC, Hu D, Lopez-Sendon JL, Robertson RM, Weaver D, Tendera M, Bove AA, Parkhomenko AN, Vasilieva EJ, Mendis S. Third universal definition of myocardial infarction. *Circulation*. 2012; 126(16):2020–35. [PubMed: 22923432]
14. Wald DS, Morris JK, Wald NJ, Chase AJ, Edwards RJ, Hughes LO, Berry C, Oldroyd KG. PRAMI Investigators. Randomized trial of preventive angioplasty in myocardial infarction. *N Engl J Med*. 2013; 369
15. Engstrøm T, Kelbæk H, Helqvist S, Høfsten DE, Kløvgaard L, Holmvang L, Jørgensen E, Pedersen F, Saunamäki K, Clemmensen P, De Backer O, Ravkilde J, Tilsted HH, Villadsen AB, Aarøe J, Jensen SE, Raungaard B, Køber L. DANAMI-3—PRIMULTI Investigators. Complete revascularisation versus treatment of the culprit lesion only in patients with ST-segment elevation myocardial infarction and multivessel disease (DANAMI-3—PRIMULTI): an open-label, randomised controlled trial. *Lancet*. 2015; 386:665–71. [PubMed: 26347918]
16. Sara JD, Eleid MF, Gulati R, Holmes DR Jr. Sudden cardiac death from the perspective of coronary artery disease. *Mayo Clin Proc*. 2014; 89:1685–98. [PubMed: 25440727]
17. Ramirez D, Engel KG, Tang TS. Language interpreter utilization in the emergency department setting: a clinical review. *J Health Care Poor Underserved*. 2008; 19:352–62. [PubMed: 18469408]
18. Attenello FJ, Wen T, Cen SY, Ng A, Kim-Tenser M, Sanossian N, Amar AP, Mack WJ. Incidence of “never events” among weekend admissions versus weekday admissions to US hospitals: national analysis. *BMJ*. 2015; 350:h1460. [PubMed: 25876878]
19. Thomas JL, Bosson N, Kaji AH, Ji Y, Sung G, Shavelle DM, French WJ, Koenig W, Niemann JT. Treatment and outcomes of ST segment elevation myocardial infarction and out-of-hospital cardiac arrest in a regionalized system of care based on presence or absence of initial shockable cardiac arrest rhythm. *Am J Cardiol*. 2014; 114:968–71. [PubMed: 25118120]
20. Aggarwal B, Ellis SG, Lincoff AM, Kapadia SR, Cacchione J, Raymond RE, Cho L, Bajzer C, Nair R, Franco I, Simpfendorfer C, Tuzcu EM, Whitlow PL, Shishehbor MH. Cause of death within 30 days of percutaneous coronary intervention in an era of mandatory outcome reporting. *J Am Coll Cardiol*. 2013; 62(5):409–15. [PubMed: 23665371]
21. Waldo SW, McCabe JM, O'Brien C, Kennedy KF, Joynt KE, Yeh RW. Association between public reporting of outcomes with procedural management and mortality for patients with acute myocardial infarction. *J Am Coll Cardiol*. 2015; 65:1119–26. [PubMed: 25790884]

Figure 1. Flow diagram Documenting Study Inclusion and Exclusion Criteria

Abbreviations: BIDMC indicates Beth Israel Deaconess Medical Center.

Figure 2. Types of Myocardial Infarctions Suffered Among Patients

Abbreviations: UCA indicates urgent coronary angiography; MI; myocardial infarction; STEMI, ST-elevation myocardial infarction; NSTEMI; non-ST elevation myocardial infarction.

Figure 3. Etiologies of Death Adjudicated by Medical Chart Review According to Angiography Status

Abbreviations: UCA indicates urgent coronary angiography; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting.

Figure 4. Etiology of Arrest as Determined by Chart Review

Table 1
Patient Characteristics of Individuals Undergoing and Not Undergoing Urgent Coronary Angiography after Resuscitated Out-of-Hospital Cardiac Arrest*

Characteristic	Resuscitated Out-of-Hospital Cardiac Arrest (N = 323)	Urgent Coronary Angiography (n=66)	No Urgent Coronary Angiography (n=257)	P-value
Age (SD), yr	63.7 ± 17.7	60.2 ± 11.6	64.5 ± 18.8	0.07
Male sex	211 (65%)	50 (76%)	161 (63%)	0.045
Coronary Artery Disease	100 (31%)	29 (44%)	71 (28%)	0.01
Prior Stroke	33 (10%)	7 (11%)	26 (10%)	0.91
Dementia	17 (5%)	1 (2%)	16 (6%)	0.21
Shockable rhythm	140 (43%)	56 (85%)	84 (33%)	<0.0001
ST elevation	55 (17%)	39 (59%)	16 (6%)	<0.0001
Obvious non-cardiac cause of arrest	138 (43%)	2 (3%)	136 (53%)	<0.0001
Following commands post-ROSC	40 (12%)	15 (23%)	25 (10%)	0.0042
Hypotension	193 (60%)	33 (50%)	160 (62%)	0.070
Contraindication to anticoagulation	36 (11%)	4 (6%)	32 (12%)	0.080
DNR order prior to admission	7 (2%)	0 (0%)	7 (3%)	0.35
Presenting from nursing home or rehabilitation facility	40 (12%)	2 (3%)	38 (15%)	0.0097
Non-English primary language	29 (9%)	3 (5%)	26 (10%)	0.16
Presenting during daytime hours	99 (31%)	16 (24%)	83 (32%)	0.62

Abbreviations: DNR indicates do-not-resuscitate; ROSC, return of spontaneous circulation; SD, standard deviation; yr, year. All continuous data are presented as means and standard deviations and categorical data presented as counts and percentages unless otherwise indicated.

Table 2

Univariable analysis of patient characteristics.

Characteristic	Odds Ratio (95% CI)	P Value
Age, per decade	0.87 (0.75-1.01)	0.07
Male sex	1.86 (1.01-3.45)	0.048
CAD	2.05 (1.18-3.59)	0.01
Prior CVA	1.05 (0.44-2.55)	0.91
Dementia	0.23 (0.03-1.78)	0.16
Shockable rhythm	11.53 (5.61-23.73)	<0.001
ST elevation	21.76 (10.75-44.02)	<0.001
Obvious non-cardiac cause	0.03 (0.01-0.12)	<0.001
Following commands post-ROSC	2.73 (1.34-5.54)	<0.001
Hypotension	0.61 (0.35-1.05)	0.07
Contraindication to anticoagulation	0.45 (0.16-1.33)	0.15
DNR order prior to admission	<0.01 (<0.01- >100)	0.98
Nursing home or rehab	0.18 (0.04-0.77)	0.02
Non-English primary language	0.42 (0.12-1.44)	0.17
Daytime Hours	0.67 (0.36-1.25)	0.21

Abbreviations: CAD indicates coronary artery disease; CVA, cerebrovascular accident; DNR, do-not-resuscitate; ROSC, return of spontaneous circulation.

Table 3

Significant correlates of urgent coronary angiography in multivariable regression.

Characteristic	Odds Ratio (95% CI)	P Value
ST elevation	14.66 (6.28-34.24)	<0.001
Shockable rhythm	3.69 (1.52-8.97)	0.004
CAD	3.37 (1.43-7.95)	0.005
Age, per decade	0.71 (0.55-0.92)	0.01
Obvious non-cardiac cause	0.08 (0.02-0.38)	0.001

Abbreviations: CAD indicates coronary artery disease.