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# Association between coronary angiography with or without percutaneous coronary intervention and outcomes after out-of-hospital cardiac arrest[☆]

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A R T I C L E I N F O

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Cardiac arrest
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A B S T R A C T

*Aim:* The aim of our study was to assess the impact of coronary angiography (CAG) after out-of-hospital cardiac arrest (OHCA) without ST-elevation (STE).
*Methods:* Prospective observational study of adult (age ≥ 18) OHCA of presumed cardiac etiology from 1/01/2010–12/31/2014 admitted to one of 40 recognized cardiac receiving centers within a statewide resuscitation network.
*Results:* Among 11,976 cases, 1881 remained for analysis after exclusions. Of the 1230 non-STE cases, 524 (43%) underwent CAG with resultant PCI in 157 (30%). Survival in non-STE cases was: 56% in cases without CAG; 82% in cases with CAG but without PCI; and 78% in those with PCI ($p < 0.0001$). In cases without STE the aOR for survival with CAG alone was 2.34 (95% CI 1.69–3.24) and for CAG plus PCI was 1.98 (95% CI 1.26–3.09). The aOR for CPC 1/2 with CAG alone was 6.89 (95% CI 3.99–11.91) and for CAG plus PCI was 2.95 (95% CI 1.59–5.47). After propensity matching, CAG was associated with an aOR for survival of 2.10 (95% CI 1.30–3.55) and for CPC 1/2 it was 5.06 (95% CI 2.29–11.19).
*Conclusion:* In OHCA without STE, CAG was strongly and independently associated with survival regardless of whether PCI was performed. The association between CAG and positive outcomes remained after propensity matching.

## Introduction

Out-of-hospital cardiac arrest (OHCA) remains a major public health problem in the United States [1]. Successful resuscitation requires a synchronized set of interdependent actions (the “chain of survival”) which in the latest 2015 American Heart Association (AHA) Guidelines includes targeted temperature management (TTM) and coronary angiography (CAG) after return of circulation [2]. Early revascularization is thought to be the primary benefit of emergent CAG after cardiac arrest [3].

Numerous (> 15) studies have reported improved rates of survival to hospital discharge with emergent CAG in patients with ST-segment elevation (STE) [2]. As such, the AHA endorses emergent CAG for OHCA patients with suspected cardiac etiology and STE regardless of whether they are comatose or awake [2]. Several studies have reported lesions amenable to percutaneous coronary intervention (PCI) in a significant minority of patients without STE on their initial post-cardiac arrest electrocardiogram (EKG) [4–7]. While studies have associated emergent CAG in patients without STE after cardiac arrest with improved survival, PCI has not always been shown to provide added benefit [6,8].

The purpose of this study was to assess the association between CAG

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alone and CAG plus PCI on outcomes after OHCA without initial STE.

## Methods

### Setting

Arizona had 6.7 million residents in 2014 [9]. The Arizona Department of Health Services (ADHS) establishes the EMS scope of practice and provider certification. EMS protocols are implemented on regional level. Crew configuration, vehicle deployment, dispatch, and response intervals vary widely across the state and some local OHCA bypass protocols are in place. About 100 EMS agencies and 40 Cardiac Receiving Centers (CRCs) responding to approximately 80% of the Arizona's population voluntarily participated in the state-sponsored Save Hearts in Arizona Registry and Education (SHARE) Program during the study period. SHARE has been described previously [10–14]. In order to be recognized as a CRC, a hospital must have: 1) primary 24/7 PCI capability with a protocol including calling cardiology for OHCA, 2) a dedicated TTM protocol for OHCAs that remain comatose, 3) an evidence-based termination of resuscitation protocol which includes a 72-h moratorium on termination of care for patients receiving TTM, and 4) commitment to on-going data submission for all OHCA patients (www.azshare.gov). There are no specific mandates or protocols regarding the timing or selection of patients for coronary angiography. The decision is left to the treating providers which includes required cardiology involvement.

### Study design and population

This is a prospective, multicenter, observational cohort study of consecutive adult (aged ≥18 years) patients with OHCA between January 1, 2010, and December 31, 2014, who were transported initially or transferred to a CRC. Cases were excluded if prehospital resuscitation was not initiated, the cause of the arrest was presumed to be non-cardiac (e.g., known respiratory arrest, suicide, trauma, drowning, or drug overdose), the patient had a Do-Not-Resuscitate order, or the patient died in the emergency department (ED).

### Data processing and study approval

EMS data are obtained from the patient care reports and outcomes are obtained either from the hospitals or from the State Office of Vital Records. SHARE includes an Utstein-style OHCA EMS database linked with in-hospital post-arrest care and outcome data. Consistent with Utstein methodology, each OHCA in which EMS attempts resuscitation is included. EMS data are cross-referenced between first responding EMS agencies, private ambulance transport companies, and the CRC database. In order to perform continuous quality improvement for in-hospital post-arrest care a data tool was developed to collect in-hospital patient information for all OHCA patients brought to a recognized CRC. The CRC data include details on CAG including the initial EKG findings, the timing of CAG, and whether or not PCI is performed. It does not include angiographic data. It also includes the final patient outcome including the Cerebral Performance Category (CPC) score [15]. The data forms were completed by CRC clinical personnel using a secure web-based data entry system. Each hospital individual completing data forms was trained in person and each form was secondarily reviewed by a SHARE data coordinator for completeness and accuracy before entry into the database. Any inconsistencies were addressed in follow-up by examining the hospital medical record.

SHARE is an Arizona Department of Health Services–sponsored public health initiative. As such the program is exempt from the requirements of the Health Insurance Portability and Accountability Act, which allows linkage of EMS and hospital data, tracking of OHCA events, and evaluation of efforts to improve resuscitation care. The University of Arizona Institutional Review Board and the Arizona Department of Health Services Human Subjects Review Board have determined that, by virtue of being a public health initiative, neither the interventions nor their evaluation constitute human subjects research and have approved the publication of de-identified data.

**Table 1**
Demographics and event characteristics.

| | N = 1881 | |
|---|---|---|
| | n (%) | Missing, n (%) |
| Male | 1289 (68.5) | 0 |
| Age, yrs-median (Q1, Q3) | 63.0 (52.0, 72.0) | 0 |
| Arrest witnessed | 837 (63.3) | 559 (29.7) |
| Bystander CPR performed | 677 (53.5) | 615 (32.7) |
| Initial rhythm VF/VT | 930 (52.6) | 113 (6.0) |
| No-STEMI | 1230 (71.1) | 152 (8.1) |
| Intervention | | |
| CAG[a] with PCI[b] | 482 (25.6) | 0 |
| CAG without PCI | 525 (27.9) | |
| No CAG | 874 (46.5) | |
| GCS | | |
| < =8 | 1427 (86.6) | 233 (12.4) |
| > 8 | 221 (13.4) | |
| Targeted temperature management | 655 (34.8) | 0 |
| Survival | 1192 (63.4) | 0 |
| Response Interval, minutes- median (Q1, Q3) | 5.0 (4.0, 6.0) | 568 (30.2) |
| CPC scale | | |
| All | 1822 (96.9) | 59 (3.1) |
| 1 | 740 (40.6) | |
| 2 | 182 (10.0) | |
| 3 | 62 (3.4) | |
| 4 | 149 (8.2) | |
| 5 | 689 (37.8) | |

[a] CAG – coronary angiography.
[b] PCI – percutaneous coronary intervention.

### Statistical analysis

To maximize the available subjects for analysis, multiple imputation was carried out in SAS (SAS, Version 9.3, SAS Institute, Cary, North Carolina) to impute missing data. Multiple imputation (MI) has been shown to generate less biased estimates with more statistical efficiency when compared with alternative methods of handling incomplete data (e.g., complete-case analysis, single imputation, missing indicator regression) [16,17]. MI involves three distinct phases: 1) the missing data are filled in $m$ times to generate $m$ complete data sets, 2) the $m$ datasets are analyzed by using standard procedures, and 3) the results from the $m$ complete datasets are combined for the inference. MI procedure replaces each missing value with a set of plausible values that represent the uncertainty about the right value to impute, instead of filling in a single value for each missing value. We used all the variables in Table 1 for MI. Twenty imputed data sets were generated and model fit and diagnostics were evaluated. Missing data fit an arbitrary missing pattern and we used Fully Conditional Specification method to impute data. Linear regression was used to impute all time intervals. Logistic regression was used to impute categorical variables, witnessed arrest, bystander cardiopulmonary resuscitation (CPR), shockable rhythm and STE.

The study population was divided into three groups, patients without CAG (reference group), patients with CAG and without PCI, and patients with CAG and PCI. Descriptive statistics were used to describe the study population and are reported as proportion for categorical and binary data and as median and interquartile range for continuous data. All analyses used the imputed data, accounting for variance across imputed data sets using Rubin's rules [18] (using Proc MI in SAS). To control for indication bias, propensity score was calculated to predict the probability of receiving CAG using a multivariable logistic regression model, including age, gender, bystander CPR