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# Should We Perform an Immediate Coronary Angiogram in All Patients After Cardiac Arrest?

## Insights From a Large French Registry

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## ABSTRACT

**OBJECTIVES** This study sought to assess the relationship between an immediate invasive strategy and survival after an out-of-hospital cardiac arrest (OHCA) of presumed cardiac cause, according to prognosis evaluated on hospital arrival.

**BACKGROUND** An immediate coronary angiogram (CAG) may be associated with better outcome after OHCA in neurologically preserved patients but could be futile in other cases.

**METHODS** From May 2011 to May 2015, we collected data for all patients admitted in hospital after OHCA in Paris and its suburbs (France). Risk of in-hospital death was retrospectively calculated using the validated Cardiac Arrest Hospital Prognosis score, which includes age, setting, initial rhythm, durations from collapse to basic life support and from basic life support to return of spontaneous circulation, pH, and epinephrine dose. Independent predictors of survival at discharge (including immediate CAG) were assessed in multivariate logistic regression in each of the 3 pre-defined subgroups of Cardiac Arrest Hospital Prognosis score: low risk (<150 points), medium risk (150 to 200 points), and high risk (>200 points) for in-hospital death.

**RESULTS** A total of 1,410 patients were included and overall survival rate at hospital discharge was 32%. Distribution in the low-, medium-, and high-risk Cardiac Arrest Hospital Prognosis subgroups was 667 (47%), 469 (33%), and 274 patients (20%), respectively. The rate of early CAG was 86%, 66%, and 47% in the low-, medium-, and high-risk subgroups, respectively ($p < 0.001$). Early invasive strategy was independently associated with better survival in low-risk patients (odds ratio: 2.3; 95% confidence interval: 1.4 to 3.9; $p = 0.001$), but not in medium-risk ($p = 0.55$) and high-risk ($p = 0.43$) patients. Sensitivity analysis found consistent results.

**CONCLUSIONS** In cardiac arrest patients, our results suggest that investigations regarding early CAG after OHCA should focus on patients with preserved neurological status. (J Am Coll Cardiol Intv 2018;11:249–56) © 2018 by the American College of Cardiology Foundation.


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**ABBREVIATIONS AND ACRONYMS**

**BLS** = basic life support

**CAG** = coronary angiogram

**CAHP** = cardiac arrest hospital prognosis

**CI** = confidence interval

**CPC** = cerebral performance categories

**CPR** = cardiopulmonary resuscitation

**ECG** = electrocardiogram

**OHCA** = out-of-hospital cardiac arrest

**OR** = odds ratio

**PCI** = percutaneous coronary intervention

**RCT** = randomized controlled trial

**ROSC** = return of spontaneous circulation

**TTM** = targeted temperature management

Out-of-hospital cardiac arrest (OHCA) affects 250,000 persons each year in the United States and Europe (1). Despite recent improvements, the prognosis of these patients remains very poor, even when a return of spontaneous circulation (ROSC) has been obtained. Most of these resuscitated patients are still comatose at time of hospital arrival and most of them subsequently die during the hospital course because of irreversible neurological damages (2). In these resuscitated patients, 2015 guidelines of the International Liaison Committee On Resuscitation highlighted the need for a comprehensive etiologic work-up, aiming to find reversible causes (3,4). Considering that coronary disease is the predominant cause of OHCA (5), these guidelines (3,4) suggest performing an immediate coronary angiogram (CAG) in patients with stable ROSC obtained after an OHCA of suspected cardiac origin. Indeed several studies have shown an association between early CAG and better survival. Even if not firmly established, the benefit of this invasive strategy is likely to result from an improvement in myocardial and circulatory status provided by percutaneous coronary intervention (PCI) (6–8).

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However, this invasive strategy is debated, because its use in routine practice is associated with several logistical and organizational problems that challenge 2015 guidelines. Moreover, CAG could delay therapeutic hypothermia and other post-resuscitation care, with potential harm for neurologically injured patients. Currently the process used to select the best candidates for such an early invasive strategy is based on the prediction of a coronary cause, considering clinical prodromes (9) and/or electrocardiogram (ECG) pattern (7,10). However, prognosis after OHCA is strongly driven by neurological damage, and anoxic-ischemic brain injury accounts for most deaths during hospitalization (2,11,12). Patients with most severe neurological damage may die from brain injury regardless of their coronary status, and PCI might be futile in too severely injured patients. Surprisingly no study has investigated the selection of candidates for an early invasive strategy based on their prognosis assessed at time of hospital admission. Using simple clinical and biological admission parameters, the Cardiac Arrest Hospital Prognosis (CAHP) score (13) proved a high discrimination value to stratify neurological outcome after OHCA. This score identified 3 groups of patients according to their outcome (low risk, 40% of unfavorable outcome; medium risk, 80%; and high risk, 95% to 100%). We assessed the value of this score in the decision process for an early invasive strategy in survivors of OHCA transported to hospital.

## METHODS

The methodology of this study is consistent with the STROBE checklist for observational studies (14).

**STUDY SETTING.** In Paris and its surrounding suburbs (Hauts-de-Seine, Seine-Saint-Denis, Val-de-Marne), management of OHCA involves mobile emergency units and fire departments, covering 762 km$^2$ and a population of 6.6 million inhabitants. The Emergency Medical Service is a 2-tiered physician-manned system, with a basic life support (BLS) tier served by firefighters of the Brigade de Sapeurs Pompiers de Paris, who can apply automated external defibrillators, and an advanced cardiac life support tier, provided in the field, with systematic endotracheal intubation, intravenous access line, and drugs if necessary. Out-of-hospital resuscitation is delivered by an emergency team including at least 1 trained physician in emergency medicine according to the international guidelines (15). Patients with ROSC are then transferred to a tertiary center with an intensive care unit and coronary intervention facilities. Decision to use an early invasive strategy, including CAG and PCI, is left to the discretion of the physician in charge. After the procedure, patients are admitted to the intensive care unit for supportive treatments (4).

All OHCA occurring in Paris and its suburbs are recorded in a prospective population-based registry system managed by the Paris-Sudden Death Expertise Center, created in May 2011 and previously described (13,16,17). Appropriate review boards approved the investigation (CNIL approval 912309; CCTIRS approval 12336).

**STUDY POPULATION.** According to recent guidelines (1), every case of OHCA (defined as unexpected death without obvious extracardiac cause, such as drowning, trauma, hanging, intoxication) was recorded in the Paris-Sudden Death Expertise Center registry. In this study, we included patients admitted alive to hospital after an OHCA, with sustainable ROSC and available CAHP score value, from May 15, 2011, to May 15, 2015.

Exclusion criteria were age younger than 18 years, OHCA occurring outside the area of interest, prior terminal condition (e.g., metastatic malignancy), obvious noncardiac cause according to Utstein templates, patients who died before hospital admission, and refractory OHCA without sustained ROSC at admission.

**DATA COLLECTION AND DEFINITIONS.** According to the Utstein style (18), the following variables are collected in the Paris-Sudden Death Expertise Center registry: age, sex, occurrence at home, witnessed status, bystander cardiopulmonary resuscitation (CPR), initial cardiac rhythm, cumulative epinephrine dose used during resuscitation, delays from collapse-to-BLS and from BLS-to-ROSC, ST-segment elevation or left bundle branch block on the post-ROSC ECG, arterial pH at admission, targeted temperature management (TTM), and coronary interventions. TTM is a standard of care, performed in most patients after cardiac arrest, mostly with external cooling methods (16,19). Early invasive strategy was defined as coronary angiography (followed by PCI if indicated) performed in the very first hours following hospital admission (20). Post-resuscitation shock was defined as the occurrence or persistence of arterial hypotension (mean arterial pressure <60 mm Hg or systolic blood pressure <90 mm Hg) sustained for more than 6 h after ROSC despite adequate fluid resuscitation (21).

The available definition and data collection approaches were constant during the period of the study. Two investigators reviewed each record for data completion and validity.

**OUTCOME.** The primary outcome was survival at hospital discharge based on review of hospital records. Neurological status was assessed by investigators, using the 5-level Cerebral Performance Category (CPC) scale (22), with a CPC level of 1 (good recovery) or 2 (moderate disability) classified as favorable neurological status, and a CPC level of 3 (severe disability), 4 (vegetative state), and 5 (death) classified as unfavorable neurological status.

**CAHP SCORE.** The CAHP score is a simple and objective score based on admission parameters, which permits prediction of the neurological outcome in patients admitted to hospital following OHCA (13). It includes 7 variables associated with poor prognosis (age, nonshockable rhythm, time from collapse-to-BLS, time from BLS-to-ROSC, location of cardiac arrest, epinephrine dose used during resuscitation, and arterial pH) (Online Table 1), and has a high discrimination value. C-statistic reached 0.93 (95% confidence interval [CI]: 0.91 to 0.95) in the development cohort, and 0.91 (95% CI: 0.88 to 0.93) in the prospective validation cohort. Calibration of the CAHP score was satisfactory (evaluated with chi-square Hosmer-Lemeshow). It has been proposed as a potentially useful tool for stratification of high-risk patients in clinical trials (23). In this study, we calculated the CAHP score for every patient included and, as previously described, we divided the population into 3 groups (CAHP score <150, from 150 to 200, and >200) (13), according to their outcome: low risk, 40% of unfavorable outcome; medium risk, 80%; and high risk, 95% to 100%. We compared patients according to these subgroups.

**STATISTICAL ANALYSIS.** Continuous data were expressed as mean ± SD. Categorical data were expressed as frequencies and percentages. We checked the linearity of quantitative variables using fractional polynomial regression. In the case of absence of linearity, continuous variables were dichotomized according to their median. Comparisons used the chi-square test for categorical variables and Student *t* test or Mann-Whitney Wilcoxon test, when appropriate, for continuous variables.

Variables associated with survival at discharge (with $p < 0.15$) in univariate analysis were assessed in multivariate logistic regression. We initially performed multivariate logistic regression in the whole population.

We then performed multivariate logistic regression, among each subgroup of CAHP score (<150, 150 to 200, >200), after adjustment for factors associated with survival in univariate analysis (excluding factors already included in the CAHP score calculation to avoid overadjustment).

Finally, 2 sensitivity analysis were performed. Considering that both European (4) and North American (3) guidelines underlined the ongoing controversy regarding emergency cardiac catheterization in patients without ST-segment elevation at admission, we performed, as a first sensitivity analysis, a multivariate logistic regression restricted to patients without ST-segment elevation on the post-ROSC ECG. Secondly, sensitivity analysis using favorable neurological status at hospital discharge as endpoint (instead of survival at hospital discharge) was performed, comparing CPC 1 to 2 with 3 to 5.

Variables were considered statistically significant for $p < 0.05$. All analyses were 2-sided. Statistical analysis was performed using STATA version 14.1 (StataCorp, College Station, Texas).

## RESULTS

Between May 2011 and May 2015, a total of 7,835 OHCA with resuscitation attempts occurred in the study area. After exclusion of patients who died

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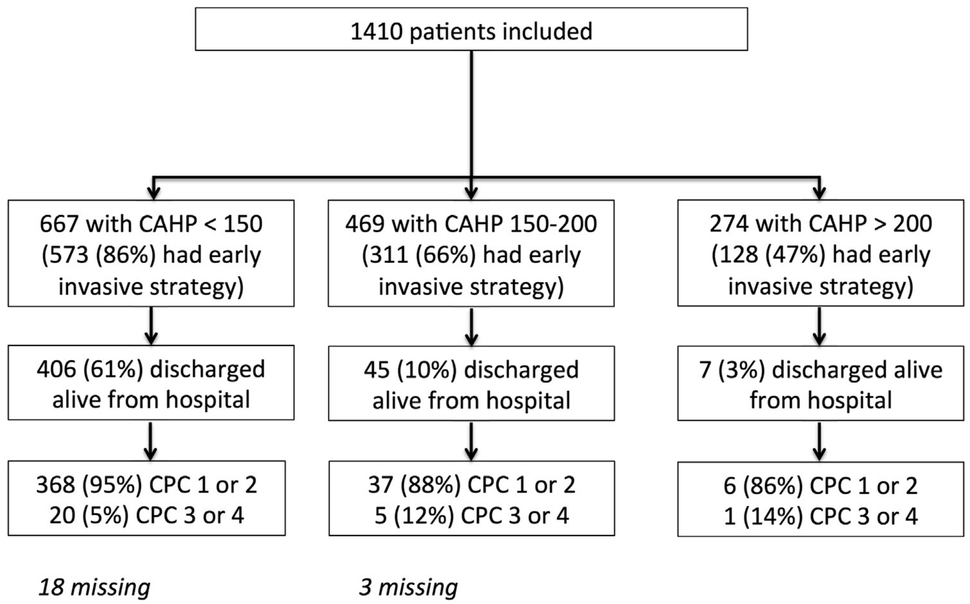
**FIGURE 1** Flow Chart of the Study, From May 2011 to May 2015




Patients included in this study from May 2011 to May 2015, and their outcome according to subgroups of CAHP score previously described (CAHP >150, low risk of unfavorable outcome; CAHP 150 to 200, medium risk; CAHP <200, high risk). CAHP = cardiac arrest hospital prognosis; CPC = cerebral performance categories.

before hospital admission, or refractory OHCA without sustainable ROSC, 1,410 patients were included in this study (Figure 1).

**BASELINE CHARACTERISTICS.** Patients included in this study were mostly male (69%) with median age of 62 years. Delays from OHCA to CPR and from CPR to ROCS were 5 min (interquartile range: 0 to 10 min) and 20 min (interquartile range: 12 to 30 min), respectively. A total of 41% of patients had ST-segment elevation on the post-ROSC ECG. Survival among patients with ST-segment elevation was 44%, compared with 27% among patients without ST-segment elevation ($p < 0.001$). A total of 667 patients (47%) had a CAHP score lower than 150 (indicating a low risk of poor neurological outcome at discharge), 469 (33%) had CAHP score between 150 and 200 (indicating a medium risk of poor neurological outcome at discharge), and 274 patients (20%) had CAHP score >200 (indicating a high risk of poor neurological outcome at discharge). During the in-hospital course, 1,012 patients (72%) were managed with an early invasive strategy, finding 31% of single-vessel disease, 32% of multivessel disease, and 37% of normal procedure. A culprit lesion was found in 422 patients, mostly on the left anterior descending artery (209 cases; 50%) or right coronary artery (99 patients; 23%). In patients managed with early CAG, 401 of 1,012 (40%) survived to hospital discharge, compared with 57 of 398 patients without early CAG (13%; $p < 0.001$). In addition, 944 patients were treated with TTM. Overall 458 patients (32%) were discharged alive, including 411 of 437 (94%) patients with favorable neurological status (CPC missing for 21 survivors). Baseline characteristics according to each subgroup of CAHP score are described in Table 1.

**PROGNOSTIC FACTORS IN THE WHOLE POPULATION.** Among the 1,410 patients included in this study, we performed univariate and multivariate analysis of factors associated with survival at discharge (Table 2). After multivariate analysis, bystander CPR (odds ratio [OR]: 1.6) and initial shockable rhythm (OR: 4.5) were both associated with a better survival at discharge. Age (OR: 0.96 per year), occurrence at home (OR: 0.5), delay for cardiac arrest to CPR over 4 min (OR: 0.5), delay from CPR to ROSC over 20 min (OR: 0.3), and a cumulative epinephrine dose more than 3 mg (OR: 0.2) were all negatively associated with survival. In this whole population, the use of an early invasive strategy was not associated with survival (OR: 1.2).

**TABLE 1 Baseline Characteristics of Patients Included According to CAHP Score**

| | CAHP Score <150 (n = 667) | CAHP Score 150-200 (n = 469) | CAHP Score >200 (n = 274) | p Value |
|---|---|---|---|---|
| Male | 500 (75) | 313 (67) | 159 (58) | <0.001 |
| Age, yrs | 57 (48–67) | 65 (54–75) | 69 (59–78) | <0.001 |
| Occurrence at home | 239 (36) | 316 (67) | 239 (87) | <0.001 |
| Witnessed | 661 (99) | 449 (96) | 244 (89) | <0.001 |
| Bystander CPR before EMS arrival | 501 (76) | 293 (65) | 113 (46) | <0.001 |
| Initial shockable rhythm | 519 (78) | 162 (35) | 31 (11) | <0.001 |
| Time from CA to CPR >4 min | 246 (37) | 264 (56) | 213 (78) | <0.001 |
| Time from CPR to ROSC >20 min | 155 (23) | 275 (59) | 212 (77) | <0.001 |
| Use of epinephrine | 277 (42) | 452 (96) | 274 (100) | <0.001 |
| pH | 7.29 (7.21–7.36) | 7.17 (7.07–7.27) | 7.05 (6.9–7.17) | <0.001 |
| Early invasive strategy | 573 (86) | 311 (66) | 128 (47) | <0.001 |
| Targeted temperature management | 495 (77) | 305 (66) | 144 (54) | <0.001 |

Values are n (%) or median (interquartile range).

CA = cardiac arrest; CAHP = cardiac arrest hospital prognosis; CPR = cardiopulmonary resuscitation; EMS = emergency medical services; ROSC = return of spontaneous circulation.

**PROGNOSTIC VALUE OF AN EARLY INVASIVE STRATEGY ACCORDING TO CAHP SCORE.** We compared subgroups according to the CAHP score (Table 3). The rate of early invasive strategies significantly differed across groups (86% in patients with CAHP score <150, 66% in patients with CAHP score between 150 and 200, and 47% in patients with CAHP score >200; p < 0.001). Rates of PCI also differed across groups: 282 of 667 (42%) for CAHP <150, 99 of 469 (21%) for CAHP from 150 to 200, and 41 of 274 (15%) for CAHP >200 (p < 0.001).

After adjustment for sex, bystander CPR, TTM, and post-resuscitation shock, early invasive strategy was significantly associated with a better survival in low-risk patients (i.e., those with a CAHP score <150; OR: 2.3) (Table 3). By contrast, no significant association between early invasive strategy and survival was found for those with medium and high risk of poor neurological outcome (p = 0.55 for CAHP score between 150 and 200; p = 0.43 for CAHP score >200). By contrast, no association between TTM and survival was found in any of the 3 subgroups.

Sensitivity analysis using favorable neurological outcome (CPC 1 and 2) as endpoint found consistent results, with a significant association between early invasive strategy and favorable outcome for CAHP score <150 (OR: 3.1), but no significant association for patients with a higher CAHP score.

**SENSITIVITY ANALYSIS RESTRICTED TO PATIENTS WITHOUT ST-SEGMENT ELEVATION ON INITIAL ECG.** Among patients without ST-segment elevation, 392 of 665 (59%) were managed with an early invasive strategy (74% of patients with CAHP score <150, 54% of patients with CAHP score 150 to 200, and 40% of patients with CAHP score >200; p < 0.001). In this population, using an early invasive strategy was significantly associated with survival (OR: 2.2; 95% CI: 1.2 to 4.2; p = 0.01) in patients with CAHP score <150. This association was not found in the 2 other subgroups of CAHP score. Sensitivity analysis using favorable neurological outcome (CPC 1 and 2) as endpoint found consistent results, with a significant association between early invasive strategy and outcome when the CAHP score was lower than 150 (OR: 3.1; 95% CI: 1.6 to 6.0; p = 0.001), but no significant association for patients with higher CAHP score values.

## DISCUSSION

In this study, using a large unselected population-based registry, we assessed the association between

**TABLE 2 Univariate and Multivariate Analysis of Prognosis Factors Associated With Survival at Hospital Discharge in the Whole Population (N = 1,410)**

| | Univariate Analysis | | Multivariate Analysis | |
|---|---|---|---|---|
| | OR (95% CI) | p Value | OR (95% CI) | p Value |
| Male | 1.6 (1.3–2.1) | <0.001 | 1.0 (0.7–1.5) | 0.81 |
| Age, per year | 0.96 (0.96–0.97) | <0.001 | 0.96 (0.95–0.97) | <0.001 |
| Home location | 0.3 (0.2–0.4) | <0.001 | 0.5 (0.4–0.7) | <0.001 |
| Bystander CPR | 2.3 (1.8–3.0) | <0.001 | 1.6 (1.1–2.5) | 0.02 |
| Initial shockable rhythm | 7.6 (5.8–10.0) | <0.001 | 4.5 (3.1–6.4) | <0.001 |
| CA to CPR >4 min | 0.4 (0.3–0.5) | <0.001 | 0.5 (0.4–0.7) | <0.001 |
| CPR to ROSC >20 min | 0.2 (0.2–0.3) | <0.001 | 0.3 (0.2–0.4) | <0.001 |
| Epinephrine dose >3 mg | 0.1 (0.1–0.2) | <0.001 | 0.2 (0.1–0.3) | <0.001 |
| TTM | 2.0 (1.5–2.6) | <0.001 | 1.1 (0.8–1.7) | 0.46 |
| Early invasive strategy | 3.9 (2.9–5.3) | <0.001 | 1.2 (0.8–1.9) | 0.35 |

Multivariable model included sex, age, location, bystander CPR, initial rhythm, delays from CA to CPR and from CPR to ROSC, epinephrine dose, TTM, and early invasive strategy.

CI = confidence interval; OR = odds ratio; TTM = targeted temperature management; other abbreviations as in Table 1.

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**TABLE 3 Association Between Early Invasive Strategy and Outcome, According to CAHP Score**

| CAHP Score | Number CAG/Patients | OR | 95% CI | p Value |
|---|---|---|---|---|
| Survival | | | | |
| <150 | 573/667 (86%) | 2.3 | 1.4–3.9 | 0.001 |
| 150–200 | 311/469 (66%) | 1.3 | 0.6–2.9 | 0.55 |
| >200 | 128/274 (47%) | 2.1 | 0.3–12.5 | 0.43 |
| Favorable neurological outcome | | | | |
| <150 | 573/667 (86%) | 3.1 | 1.8–5.3 | <0.001 |
| 150–200 | 311/469 (66%) | 1.4 | 0.6–3.5 | 0.43 |
| >200 | 128/274 (47%) | 2.1 | 0.3–12.5 | 0.43 |

OR after adjustment for sex, bystander CPR, targeted temperature management, post-resuscitation shock. CAHP score include age, nonshockable rhythm, time from collapse to basic life support, time from basic life support to return of spontaneous circulation, location of cardiac arrest, epinephrine dose, and arterial pH.

CAG = coronary angiogram; other abbreviations as in Tables 1 and 2.

the use of an early invasive strategy and survival rate after OHCA, according to the CAHP score. We demonstrated an association between the use of an early invasive strategy and survival among patients with a presumed favorable outcome (i.e., low CAHP score). By contrast, no significant association was found among patients with a presumed poor outcome (i.e., CAHP score >200). These findings suggest that the decision to perform an early invasive strategy in survivors of OHCA should not only be based on clinical and electrographic signs of an ongoing myocardial infarction, but should also integrate an evaluation of the prognosis. This may ensure avoiding unnecessary procedures in patients with minimal chances of survival, but also reinforce association between CAG and outcome in patients with preserved neurological outcome.

Selection of patients suitable for an early invasive strategy after successfully resuscitated OHCA remains challenging. Identification of the best candidates could optimize triage of OHCA patients, especially pre-hospital orientation to hospitals with a catheterization laboratory. Unnecessary procedures can induce costs and potential complications (24). In clinical practice, selection of patients is mainly focused on identification of patients who may have a culprit coronary lesion, which triggered the OHCA. To this end, several tools have been proposed with various discrimination values, such as ST-segment elevation (4,7,10,20,25) or troponin measurement (26,27). However, PCI, even successful, of a culprit coronary lesion in a patient with severe and irreversible anoxic-ischemic brain injury seems futile. Therefore, as suggested by recent guidelines (20), optimization of an early invasive strategy not only involves evaluating the probability of an ongoing infarction but could also include an evaluation of the neurological outcome. Identification of patients with a very high probability of irreversible neurological damage is a key issue in selecting patients for an invasive strategy (28,29).

We recently developed, validated, and published a simple tool, the CAHP score for early stratification of OHCA patients, with an excellent discrimination value (13). As suggested by Sunde and Andersen (23), this score does not allow individual prediction, and could lead to inappropriate withdrawal of life-sustaining therapy, with self-fulfilling prophecy. By contrast, this score could help clinicians in decision making. In our study, we demonstrated that an early invasive strategy, as recommended by guidelines (3,4), is associated with survival among patients with presumed favorable outcome. Our various sensitivity analysis (considering neurological outcome instead of survival, or restricted to patients without ST-segment elevation) found consistent results. The CAHP score could be a simple, immediately available tool to help triage OHCA patients for early invasive strategy, along with the medical history, ECG changes, and the first recorded rhythm. Patients with ST-segment elevation and assumed favorable prognosis seem best candidates for early invasive strategy, whereas performing CAG in patients without electrocardiographic sign of ongoing myocardial infarction and very high probability of irreversible neurological damage seems questionable. Accordingly, Reynolds et al. (28,30) described a lower benefit of early CAG among patients with the most severe post-cardiac arrest illness, where the main cause of death was from neurologic causes. Combination of prognostic scores available (13,28,31) could be helpful for selection of candidates for early invasive strategy.

In our study, we reported a significantly higher rate of early invasive strategies among patients with a presumed favorable outcome (86% of patients with CAHP score <150 vs. 47% of patients with CAHP score >200). This result suggests that clinicians already select patients for invasive strategy according to their presumed prognosis. This could result from a selection bias, reflecting real-life practice in which decision to perform early CAG currently involves patients' characteristics. However, despite this pragmatic selection, 128 early invasive strategies were still performed among patients with a CAHP score >200, with a final survival of 3%. In our cohort, 13% of early invasive strategies were performed in patients with highest CAHP scores (>200): these strategies are debatable, and could have been avoided with a CAHP-directed strategy. This could lead to a decrease in the number of CAGs, and could improve the cost-effectiveness of an early invasive strategy in survivors of OHCA.

The highest level of evidence is provided by randomized-controlled trials (RCTs). In the field of OHCA, several intervention RCTs have been performed, mostly with disappointing results (32–36). Currently, 6 RCTs are recruiting or close to recruiting patients to assess the value of early invasive strategy after OHCA (DISCO NCT02309151, COUPE NCT02641626, TOMAHAWK NCT02750462, PEARL NCT02387398, NCT02587494, EMERGE NCT02876458). In all of these RCTs the main inclusion criteria is based on the post-resuscitation ECG (mostly, ST-segment elevation or left bundle branch block). By contrast, to the best of our knowledge, none of these RCTs refer to severity as an inclusion or stratification criteria. Given the major differences in prognosis between subgroups of patients defined by the CAHP score, pooling such different patients could lead to issues regarding statistical power. As an example, assuming a similar hypothesis of a relative 10% increase of survival with early invasive strategy, with an alpha risk of 5% and a power of 80%, number of patients needed to treat varies from 2,000 (among selected patients with CAHP <150, survival was 60%) to 7,500 (unselected patients admitted alive, 30% survival in our study). This example strongly supports the crucial need to take into account the severity range of patients in the inclusion criteria in RCTs regarding OHCA, to avoid heterogeneity. To this end, the use of the CAHP score could be an interesting tool to design studies and stratify patients with predefined severity range.

**STUDY LIMITATIONS.** First, this study is observational and we cannot conclude about causality. However, performing a RCT in the selected subgroup with CAHP score >200 would require a huge number of patients (more than 100,000), and seems unrealistic. Second, we performed this study through a population-based registry without a homogenous algorithm of decision for early invasive strategy. Nevertheless, this registry reflects current practices in our region. Third, our results only reflect 1 emergency medical services system. Results from this study (and CAHP scoring itself) need an external validation before generalization, considering that the predictive value of the score may vary in other populations. Fourth, a high CAHP score alone cannot be used for individual prediction (e.g., to withhold acute coronary intervention). However, this score could be useful for future trials to identify subgroups of patients that might be more likely to benefit from coronary intervention. Fifth, some parameters could be missing when the patient is taken to the laboratory. To limit these missing data and enhance the ease of use, we chose a limited number of parameters (7 parameters) for the CAHP score, all available from the pre-hospital setting in most cases. Finally, absence of a significant association between early invasive strategy and survival among the highest CAHP score could result from lack of power. The very limited survival rate in this subgroup (7 patients over 274) strongly limited the analysis.

## CONCLUSIONS

In this population-based study, we assessed the potential interest of a risk-stratification approach in the decision process for early invasive strategy in OHCA patients. By using the CAHP score, which is a simple tool, we demonstrated that an early coronary invasive strategy is associated with improved survival in patients with preserved neurological outcome (i.e., those with a low CAHP score). By contrast, no significant association was found among patients with presumed pejorative outcome (CAHP score >200). Presumed outcome should be integrated in the decision for early invasive strategy in patients resuscitated of OHCA. Our results suggest that a simple prognostication score may permit avoiding unnecessary procedures in patients with minimal chances of survival, but also reinforce the association between CAG and outcome in patients with a preserved neurological outcome.

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**PERSPECTIVES**

**WHAT IS KNOWN?** Several studies have shown an association between early coronary angiogram and better survival after out-of-hospital cardiac arrest.

**WHAT IS NEW?** This study suggests that the decision to perform an early invasive strategy in survivors of cardiac arrest should not only be based on clinical and electrographic signs of an ongoing myocardial infarction, but should also integrate an evaluation of the prognosis, as provided by CAHP score.

**WHAT IS NEXT?** Optimal timing for coronary angiogram in such patients remains unclear.

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**KEY WORDS** cardiac arrest, coronary angiogram, percutaneous coronary intervention, prognosis, sudden death

**APPENDIX** For supplemental materials and a supplemental table, please see the online version of this paper.