RESEACH ARTICLE

Predictive Factors for Positive Coronary Angiography and the Role of Early Intervention After Out-of-Hospital Cardiac Arrest

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ABSTRACT

Background: In recent years, there has been considerable research in the field of post-resuscitation care. Recent guidelines recommend early coronary angiography and percutaneous coronary intervention (PCI) as the best strategy in survivors of out-of-hospital cardiac arrest (OOHCA) with ST elevation myocardial infarction (STEMI). However, there are no decisive data for patients who do not exhibit clinical and ECG criteria suggestive of STEMI. We sought to review current evidence regarding the predictive factors of positive coronary angiography and the role of early PCI in an OOHCA setting.

Methods & Results: Between 1995 & 2014, we identified 35 studies reporting on adult survivors of OOHCA who underwent coronary angiography and PCI. In total, there are over 16,000 patients included in reported series of resuscitated OOHCA victims who have undergone coronary angiography and PCI when indicated. PCI was successful in 92% (51-100%) of the attempted cases. The survival rate was 64% (22% - 88%) with a satisfactory neurological outcome at follow-up that varied from 47-96%. As the survival benefit seems to be time dependent, the selection of which patients are candidates for early PCI is under considerable research. Predictive factors for positive coronary angiography and outcome were ventricular fibrillation, history of coronary heart disease and diabetes, ST elevation on ECG, male gender, and intact brain stem functions. Negative predictive factors were normal ECG on admission or plain repolarization abnormalities, and loss of brain stem functions.

Conclusions: Early coronary angiography and PCI is a promising management strategy in the OOHCA setting. As there is evidence that the survival benefit from PCI is time dependent, the research is still ongoing in identifying which patients would benefit most from an aggressive revascularization approach. (***Rhythmos*** 2015;10 (3): 53-61)

Key words: cardiac arrest; post-resuscitation care; coronary heart disease; coronary angiography; primary angioplasty

Abbreviations: ECG = electrocardiogram; MTH = mild therapeutic hypothermia**;** OOHCA = out-of-hospital cardiac arrest**;** PCI = percutaneous coronary angiography**;** ROSC = return of spontaneous circulation; STEMI = ST elevation myocardial infarction

INTRODUCTION

Cardiac arrest is a global health issue with an enormous social and economical impact. Every year approximately 490,000 Europeans suffer from cardiac arrest,[1] and their prognosis has remained dismal through the years.[2] Despite public education programs and the widespread use of automatic external defibrillators, few patients are admitted to hospital, and even fewer are discharged alive with a favorable neurological outcome.

Recently, there is a trend towards increased survival through well-organized bundles of post resuscitation care that include mild therapeutic hypothermia (MTH) or at least maintenance of normothermia and percutaneous coronary intervention (PCI).[3-5] Several studies report better survival rates and improved neurological outcomes after successful application of PCI, establishing this approach as a vital link in the standard post resuscitation care.

As the majority of OOHCA is of primary cardiac origin,[6] several researchers recommend the routine application of coronary angiography with subsequent PCI, if indicated, in every resuscitated cardiac arrest victim, regardless of symptoms or ECG findings.[7-9] However, coronary angiography is an interventional procedure, which carries its own risks and complications. An unnecessary transfer of a comatose ventilated patient to the catheterization laboratory might have the opposite results, causing delays in diagnosis and therapy.[10]Therefore, before we could institute a routine interventional protocol for victims of OOHCA, we should have clear evidence of which patient would benefit from such an aggressive, interventional approach. Hence, this research was undertaken with the aim to sort out data about the predictive factors of positive coronary angiography that would render selection plausible for an interventional approach to victims of cardiac arrest after return of spontaneous circulation (ROSC).

DATA SOURCES – STUDY SELECTION

The studies for our review were identified from PubMed and references from relevant studies and review papers. Search terms included: “cardiac arrest”, “coronary angiography”, “coronary angioplasty”, “electrocardiography” and combinations of these terms. Two independent reviewers did literature searches and identified the studies surveyed. A study was eligible for inclusion in the review, if it assessed the role of early coronary angiography and PCI in an OOHCA setting. This review expands on a prior study, [11] albeit with a

main focus on predictive factors of findings of early coronary angiography.

URGENT CORONARY ANGIOGRAPHY AND PCI IN SURVIVORS OF OOHCA WITH STEMI

Nowadays, patients with STEMI are treated with an aggressive revascularization strategy resulting in high success and survival rates.[12] Unfortunately, for many years, there was no clear evidence of the applicability of PCI in an OOHCA setting, due to a variety of reasons. Firstly, OOHCA patients were virtually excluded from most revascularization studies due to selection criteria. Secondly, the transfer of such critically ill patients to PCI capable centers presented logistical difficulties.[13] In addition, emergency physicians and interventional cardiologists were reluctant to perform urgent coronary angiography and PCI in a comatose patient because of the uncertainty regarding the prognosis and the neurological recovery.[8]

Thus, the prognostic value of acute coronary angiography and PCI following ROSC after OOHCA is less clear compared to the population of STEMI without cardiac arrest, especially in comatose survivors. This scenario was evaluated in the 2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations.[14]The recommendation was to consider acute coronary angiography in STEMI or with clinical suspicion of coronary ischemia as a likely cause of the arrest, and that it may be reasonable to include this approach in a systematic standardized post cardiac arrest protocol. Further evidence that has meanwhile emerged is herein reviewed.

Kahn et al were the first to perform urgent coronary angiography in 11 selected patients resuscitated from OOHCA.[15] All patients presented with ventricular fibrillation and had evidence of STEMI at the post arrest ECG. Seven patients underwent successful PCI, and 6 of them were finally discharged alive. Despite the fact that 4 patients were unresponsive on admission, all survived without major neurological sequelae. Although the number of patients in this study was small, the authors were the first to show that coronary angiography with subsequent PCI is a realistic therapeutic approach, regardless of the neurological status upon admission.

Spaulding et al performed urgent coronary angiography in 84 victims of OOHCA.[7] PCI was performed successfully in 37 (44%) with a survival rate of 38% (32 out of 84). The authors questioned the utility of the clinical and ECG criteria in detecting an acute coronary syndrome and recommended the routine application of coronary angiography in every resuscitated victim of OOHCA.

Several studies followed, reporting the rather consisting finding of increased survival with the application of PCI.[7-9,13, 15-37, 39-45] Gorjup et al[20] reported on the outcome of patients with STEMI with or without cardiac arrest. Patients who regained consciousness before admission had excellent survival rates and the success of PCI was comparable to that of STEMI patients without cardiac arrest (100% vs 98%, p = 0.20). In patients who remained comatose, the survival rate was lower, but significantly improved with respect to that historically reported. Mager et al compared the mortality of 21 patients with STEMI who survived cardiac arrest with the mortality of 927 STEMI patients without cardiac arrest, after they excluded patients with cardiogenic shock.[27] Interestingly, cardiac mortality was similarly low in the two groups (0 vs 2%, P=NS), while the noncardiac mortality (14.3 vs 1.2%, P=0.001) accounted for the difference in total one-month mortality rate being higher in the resuscitated patients (14.3 vs 3.4%, P=0.033). Predictors of poor outcome in the resuscitated patients were older age (r=0.47, P=0.032), unwitnessed sudden death (r=0.44, P=0.04), longer interval between onset of cardiac arrest and arrival of a mobile unit (r=0.67, P=0.001) or to ROSC (r=0.65, P=0.001), low glomerular filtration rate (r=-0.50, P=0.02), and the initial TIMI grade of flow (r=-0.51, P=0.017). In the largest study to date, Dumas et al published a series of 435 patients who underwent routine coronary angiography after successful ROSC.[9] Of 435 patients, at least one significant coronary lesion was found in 304 (70%), PCI was successful in 177 (58%) and the overall survival was 39%.

The neurological outcome is not reported uniformly across all studies, but there is evidence that PCI confers an improved survival rate, regardless of the neurological status. Hosmane et al performed coronary angiography in 98 resuscitated patients with STEMI with an overall survival rate of 64%.[29] As the majority of patients who were unresponsive on admission recovered fully at follow-up, the researchers also recommended a more aggressive approach, irrespective of the neurological status. Lettieri et al, who reported on 99 STEMI patients resuscitated from OOHCA and transferred for PCI, came to a similar conclusion.[28] Out of 77 patients who survived, 67 (87%) recovered fully and were leading a normal life at the one-year follow-up. Interestingly, from the 20 patients with Glasgow coma scale 3 on admission, one died and only 6 remained with permanent neurological disability. Keelan et al, in their study of 15 OOHCA patients who underwent PCI, reported that although the initial neurologic condition was poor in 6 patients, the majority exhibited a complete neurological recovery at follow up.[17]

Theoretically, the most promising post resuscitation strategy is the combination of mild therapeutic hypothermia (MTH) with urgent coronary revascularization. Mild therapeutic hypothermia is a well-

established neuroprotective therapy that may result in complications such as coagulation disorders and arrhythmias. The combination of MTH with PCI could synergistically increase these adverse effects. There have been several reports of MTH utilization during PCI but none studied that approach in a systematic fashion. Batista et al studied the combination of MTH with PCI after cardiac arrest. In their study of 91 cardiac arrest patients who underwent PCI, the concomitant application of MTH was not associated with serious arrhythmic or hematological complications.[31] More recently, concern has been raised with regards to coronary stent thrombosis associated with cardiac arrest and use of MTH, however that cohort had not received dual antiplatelet therapy, which is of paramount importance to prevent this adverse effect, while the majority of patients in this study were in cardiogenic shock.[38] Nevertheless, more data are being accumulated suggesting that normothermia, or at least avoidance of hyperthermia may be a better or alternative to MTH strategy in OOHCA victims.[5]

According with the EUROTRANSFER Registry data, 42 of 1650 patients with STEMI transferred for PCI were victims of OOHCA. Cardiogenic shock on admission or acute heart failure was more frequently observed in OOHCA group. In-hospital mortality was similar, but 1-year mortality was higher at 19.1% in the OOHCA group vs 8.1% ($p = 0.011$).[39] However, resuscitation prior to coronary angiography was not an independent predictor of long-term adverse outcome.

In a retrospective study of 93 OOHCA victims (67 $\pm$12 years old, 76% men) coronary angiography was performed in 66 patients (71%), in 48 acutely with successful emergency PCI in 25 patients (52%).[40] In-hospital survival rate was 54%. Emergency coronary angiography (hazard ratio 2.32) and successful emergency PCI (hazard ratio 2.54, $p = 0.004$) were independently related to in-hospital survival.

In a multicenter registry of STEMI patients, 224 patients presented with (68% prior to ambulance arrival) and 3259 without OOHCA (mean age 63 years; 75% males).[41] Culprit lesion was associated with OOHCA with the highest risk incurred by proximal left coronary lesions and lowest by right coronary lesions; culprit lesion also determining the risk of cardiogenic shock. Use of MTH was at 88%. Successful reperfusion was strongly related to survival. Survival was 83.5% (vs 96.9% in those without OOHCA). Neurological recovery was satisfactory in 77%.

However, another cohort study failed to demonstrate a strong independent impact of early PCI as part of post resuscitation care on 30-day survival with favourable neurological outcome in patients with STEMI complicated by OOHCA.[42] The study comprised 494 arrest patients with 249 (50%) having STEMI. Within 12 hours after ROSC, coronary angiography was performed in 197 (79%) and PCI in 183 (93%) (78% got PCI in <180 min). The authors concluded that a prospective randomized trial is urgently needed to shed light on this matter.

In a retrospective study, of 1011 adult survivors of in-hospital or out-of-hospital cardiac arrest, 273 (27%) undergoing immediate coronary angiography had higher rates of good outcome (odds ratio 1.92; $p = 0.006$) except for those in the most severe stratum of illness severity (11% vs. 6%; $p = 0.11$).[43] The authors concluded that the benefit of early angiography was less clear in the most severe stratum of illness, in which the high risk of mortality was primarily from neurologic causes.

Analysis of data from the CathPCI registry comparing patients undergoing PCI after OOHCA with those without OOHCA indicated that out of 594,734 patients, 114,768 had STEMI, of whom 9,375 (8.2%) had OOHCA, and 479,966 had no STEMI, of whom 2,775 (0.6%) had OOHCA.[44] Patients with OOHCA were significantly more likely to have more complex lesions with worse baseline TIMI flow, and more likely to have cardiogenic shock, both for STEMI and no STEMI. In-hospital mortality was higher in patients with OOHCA, for both STEMI (24.9% vs 3.1%) and no STEMI (18.7% vs 0.4%). The authors concluded that patients undergoing PCI after OOHCA had more complex anatomy, more shock, and higher mortality.

According to a secondary analysis of a multicenter clinical trial from North America, from 16,875 OOHCA victims, 3,981 (23.6%) had ROSC and 1,317 (33.1%) survived to hospital discharge, with 1,006 (25.3%) favorable outcomes; ~19% had early coronary angiography, ~18% PCI and ~39% MTH (39.3%).[45] Survival and favorable outcome were independently associated with early coronary angiography (odds ratios - OR 1.69 and 1.87), coronary reperfusion (OR 1.94 and 2.14), and induced hypothermia (OR 1.36 and OR 1.42). The authors concluded that early coronary intervention and MTH are associated with favorable outcome.

In total, there are over 16,400 patients included in reported series of patients resuscitated from OOHCA who have undergone coronary angiography and PCI when suitable (Table 1). Epidemiological and catheterization data can be found elsewhere.[11] Successful PCI, as it is represented by TIMI 2-3 flow, was feasible in 92% (51% - 100%) of the attempted cases. The survival rate was 64% (22% - 88%) with a satisfactory neurological outcome at discharge or at follow-up that varied from 47% to 96%.

These data should be taken into careful consideration, due to the small sample sizes and the retrospective nature of these studies. In addition, these studies were non-randomized and selection bias could also favor the

interventional approach, as patients with worse clinical outcome possibly would not be referred for emergency coronary angiography. Nevertheless, these studies support the feasibility and increased rate of success with a potential survival benefit of an early invasive/ interventional strategy. In the latest Resuscitation guidelines of 2010, the application of PCI in resuscitated patients with STEMI after OOHCA is a part of the standard post resuscitation care.[14] Thus, in patients without a discernible non-cardiac cause of cardiac arrest, acute coronary angiography with an aim towards PCI should be strongly considered irrespective of ECG findings due to a high prevalence of coronary artery disease.

ROUTINE PCI IN ALL SURVIVORS OF OOHCA

Contrary to the evidence indicating that patients with clinical or ECG criteria suggestive of STEMI would benefit from PCI, research has not reached any concrete conclusions on the remaining patients with no obvious extracardiac cause of OOHCA.Pathological[46] and clinical[7] studies have shown the presence of acute thrombosis in the coronary arteries of patients with OOHCA. Acute coronary occlusion and subsequent ischemia could be the pathophysiological substrate for the arrhythmiological death.[6]

Spaulding et al, assuming that acute coronary syndrome is the main cause of OOHCA, submitted all OOHCA victims to routine coronary angiography and performed urgent PCI when indicated.[7] With an emergency coronary angiography, the coronary anatomy could be defined and the patency of the infarct related artery could be reestablished, thus leading to hemodynamic and electrical stability. As previously mentioned, PCI had a considerable rate of success (28 out of 37, 76%) and was associated with an improved outcome. The most remarkable aspect of this study was the poor prognostic value of clinical and ECG criteria for predicting an acute coronary event. In 9 out of the 36 patients with an angiographically proven acute coronary occlusion, there were no chest pain or ECG findings. As a consequence, the authors proposed the routine application of PCI in all patients resuscitated from OOHCA, irrespective of symptoms or ECG findings, a strategy that is being adopted by several researchers.[9, 17]

These results have been recently confirmed by a similar study from the same center. Dumas et al transferred 435 patients to the catheterization laboratory.[9] Out of the 134 victims with clear evidence of STEMI, 128 (95.5%) patients had a significant coronary lesion that warranted PCI, while the same was true for 176 (58.47%) out of the 301 patients without positive ECG. Successful PCI, and not ST-segment elevation pattern on the ECG, was associated with better survival rate in both groups (51% vs 31%, $p<0.001$, 47% vs 31%, $p<0.001$). The authors concluded that an aggressive strategy of routine PCI is preferable, due to the low prognostic value of the post resuscitation ECG.[9]

A retrospective analysis (PROCAT Registry) of 1274 patients admitted after OOHCA during a 10-year period, imaging strategy being applied in 896 patients, indicated that 745 coronary angiographies were performed, of which 452 (61%) identified at least one significant coronary lesion deemed the culprit for the cardiac arrest.[47] Computed tomography, performed in 355 patients, provided a diagnosis in 72 patients (20%) (38 stroke, 19 pulmonary embolism). Survival was significantly higher for patients with a diagnosis identified by coronary angiography as compared with computed tomography (43% vs 10%, $p < 0.001$).

On the other hand, a smaller but well-organized study by Anyfantakis et al has reached conflicting results.[30] In a sample of 72 patients that have undergone coronary angiography, 27 (37.5%) patients had totally occluded arteries or irregular lesions that could easily passed with the guidewire, while 19 (26.4%) had stable coronary lesions. The authors make a clear distinction between the acute occlusion that leads to a coronary event, and the chronic lesions of stable coronary heart disease. Only 37.5% of the patients had angiographically proven myocardial infarction, while the remainder had other frequent causes of cardiac arrest, such as ischemic cardiomyopathy with reduced ejection fraction (22%), dilated cardiomyopathy (11.1%) and pulmonary embolism (5.6%). In multivariate analysis, PCI was not related to increased survival and it was not recommended as a standard procedure.[30]

As the debate continues, the research is still ongoing. Cronier et al in a series of 111 patients have shown that routine PCI is related to increased survival rate[33] (OR=0.30, p=0.001). Möllmann reached the same conclusion, by incorporating evidence from the German Registry of Cardiac Arrests.[32] In a total of 65 patients, the routine application of PCI had a better survival rate. Finally, Strote et al studied the urgency of coronary angiography after OOHCA.[36] Patients were divided in two groups: those who received acute revascularization within a 6-hour time frame, and those who received that treatment not within that time frame or not at all. The patients who underwent acute revascularization had a survival rate improvement that was statistically significant (72% vs 49%, p=0.001).

The study by Strote et al underscores the dilemma that exists towards the application of PCI in victims of cardiac arrest. As it is the case with myocardial infarction where time is precious for myocardial salvage, it seems that the same applies to these critical patients: time is survival. However, coronary angioplasty is a rather interventional procedure with potential complications. The use of

iodinated contrast agents together with the adjunctive antithrombotic therapy could have the opposite results. In addition, a routine PCI, as it is not available in all hospitals on a 24-hour basis, would demand the mobilization of complex health units in order to transfer these critically ill patients to the appropriate center. A potential referral for coronary angiography might lead to delays in the diagnosis and to the appropriate management of such patients.[10] Therefore, if we follow a strategy of early PCI, we should have clear evidence of which patient should receive that kind of treatment.

PREDICTIVE FACTORS OF POSITIVE CORONARY ANGIOGRAPHY AFTER OOHCA

In 1997, Spaulding et al were the first to study the clinical and ECG criteria for predicting positive findings on coronary angiography after OOHCA.[7] Out of the 39 patients with an angiographically proven artery occlusion, 9 did not have chest pain or ECG criteria suggestive of an acute coronary event. As the positive and negative predictive values of the clinical and ECG findings were 87% and 61 % respectively, the authors state that coronary angiography should not be restricted relying on clinical criteria alone.[7]A more recent study from the same center reaches the same conclusion. The sensitivity, specificity, positive predictive and negative predictive values were 42%, 95%, 96%, and 42% respectively.[9]

Müller et al have studied the accuracy of ECG after OOHCA.[48] The ECGs of 77 consecutive patients who were successfully resuscitated from OOHCA were reviewed retrospectively and were compared with the results of laboratory tests, coronary angiographies and autopsies. In those patients whose ECG on the field was recorded, its sensitivity, specificity, positive predictive and negative predictive values were 88%, 69%, 77%, 83% respectively. Similarly, the ECG on admission had a sensitivity, specificity, positive predictive and negative predictive values of 93%, 70%, 77%, and 90% respectively. The authors concluded that the ECG had reasonable accuracy in order to elucidate the diagnosis.

Sideris et al also studied the value of ECG after OOHCA.[49] Having in mind that ST elevation is not absolutely accurate for the diagnosis of STEMI, they extended the diagnostic criteria by including ST depressions, LBBB (combined criteria) and wide QRS (extended criteria). The diagnosis of acute myocardial infarction was made under strict criteria: only irregular lesions or those that could be easily passed with the guide wire were considered indicative of myocardial infarction, while they should also be accompanied by a respective enzymatic increase. Out of the 165 patients who were submitted to routine catheterization, 60 had acute myocardial infarction and 52 received a successful PCI. The sensitivity and specificity of ST elevation in predicting a myocardial infarction were 88% and 84% respectively, while those of the combined criteria were 100% and 46% respectively. If the combined criteria had been applied, coronary angioplasty could have been avoided in 46 patients, without losing any case of acute myocardial infarction. They concluded that the application of combined ECG criteria could aid to the appropriate triage of cardiac arrest victims and to the avoidance of unnecessary coronary angiographies. Other predictive factors for positive coronary angiography were male gender (OR: 4.2, $p=0.005$), ventricular fibrillation as first documented rhythm (OR: 7.4, $p<0.001$) and age (OR: 7.7, $p<0.001$).

Lellouche et al studied the prognostic value of various repolarization abnormalities on the post arrest ECG.[50] Like Sideris et al, they have used a rather strict definition of acute myocardial infarction: only the irregular lesions that were easily passed by the guide wire were considered indicative of myocardial infarction. They then grouped patients in four categories, according to the admission ECG: ST elevation, repolarization abnormalities, none of the above, or both. Out of the 225 patients who were successfully resuscitated, and transferred for coronary angiography, 121 had at least one acute coronary lesion. ST elevation had a positive predictive value of 79%, while the presence of repolarization abnormalities only had a negative predictive value of 85%. Patients with acute coronary syndrome were more likely to have ST elevation, while patients with isolated repolarization abnormalities were more likely to have an extracardiac cause of cardiac arrest. The conclusion was that ECG can have a reasonable diagnostic accuracy in predicting which patient would benefit from an early revascularization approach.

The predictive value of the post ROSC ECG for positive coronary angiography in cardiac arrest survivors was examined in 93 patients, 44% having ST-segment elevation and 56% having other ECG patterns.[51] Significant coronary artery disease was found in 86% of patients, in 98% of patients with ST-segment elevation and in 77% of patients with other ECG patterns ($p=0.004$). Acute or presumed recent coronary artery lesions were diagnosed in 56% of patients, in 85% of patients with ST-segment elevation and in 33% of patients with other ECG patterns ($p<0.001$). Thus, ECG had a good positive predictive value (85%) but a low negative predictive value (67%) in diagnosing the presence of acute or presumed recent coronary artery lesions. The authors concluded that ECG findings after OOHCA should not be considered as strict selection criteria for performing emergent coronary angiography, since even in the absence of ST-segment elevation on post-ROSC ECG, acute culprit coronary lesions may be uncovered.

Mager et al[27] examined the impact of emergency primary PCI on outcome in 21 patients with STEMI not complicated by cardiogenic shock who were resuscitated from cardiac arrest and compared it with the group of 921 patients with STEMI without cardiac arrest. Total one-month mortality rate was higher in the resuscitated patients (14.3 vs. 3.4%, P=0.033), mainly due to noncardiac mortality (14.3 vs. 1.2%, P=0.001) with cardiac mortality being similar (0 vs 2%). Predictors of poor outcome in the resuscitated patients were older age (r=0.47, P=0.032), unwitnessed sudden death (r=0.44, P=0.04), longer interval between onset of cardiac arrest and arrival of a mobile unit (r=0.67, P=0.001) or to ROSC (r=0.65, P=0.001), renal insufficiency (r=-0.50, P=0.02), and the initial TIMI grade of flow (r=-0.51, P=0.017).

Aurore et al examined the prognostic factors that lead to a positive coronary angiography after cardiac arrest.[52] They analyzed retrospectively the medical records of 135 patients with OOHCA who underwent coronary angiography. From the multivariate analysis, a history of coronary heart disease or diabetes mellitus had a positive predictive value of 95%, while ST elevation had a value of only 79%. Despite the fact that the number is relatively small, and the selective nature of the study weakens the results, the authors suggest that the ECG criteria are not reliable. Nevertheless, they emphasize that approximately 20% of patients had normal coronary arteries and a strategy of routine PCI would cause delays and could possibly be harmful for the patients.

In a study of 84 patients, 58% with ST elevation ECG and 41% with non-ST elevation ECG, patients with ST-elevation more frequently had obstructive coronary artery disease (89% vs 51%, p<0.001) or acute coronary occlusions (83% vs 8%, p<0.001).[53] Independent predictors of an acute coronary occlusion were chest pain before arrest (odds ratio - OR 0.16, p = 0.01), a shockable initial rhythm (OR 0.16, p = 0.03), and ST-elevation on the post-resuscitation ECG (OR 0.02, p < 0.001). Survival with favorable neurologic recovery was 59%. Independent predictors of mortality or unfavorable neurological outcome were absence of basic life support (OR 0.2, p = 0.04), prolonged resuscitation time (OR 0.9, p = 0.01), and use of vasopressors (OR 14.8, p = 0.001).

According with a retrospective analysis of 1011 adult survivors of in-hospital or out-of-hospital cardiac arrest, with 273 (27%) undergoing immediate coronary angiography, the benefit of early angiography was less clear in the most severe stratum of illness, in which the high risk of mortality was primarily from neurologic causes.[43]The authors recommend the use of the Pittsburgh Post-Cardiac Arrest Category as a risk-stratification tool to facilitate risk-adjusted assessment of outcome for post-cardiac arrest patients being considered for early invasive strategy. In this study, the Pittsburgh Cardiac Arrest Category was determined within 6 hours of cardiac arrest and defined 4 categories or strata (I-IV): (I) awake, following commands; (II) moderate coma without cardiorespiratory failure; (III) moderate coma with cardiorespiratory failure; and (IV) severe coma (loss of brainstem functions).

CONCLUSION

In recent years, there has been substantial progress in strengthening the last link in the chain of survival. The combination of early coronary angiography and PCI with MTH or at least maintaining normothermia is a promising therapeutic modality that has been successfully utilized in resuscitated patients with STEMI.[9,13,21,23,25,27-29,33] As there is evidence that the survival benefit from PCI is time dependent, there is considerable research in identifying which patients are candidates for an aggressive revascularization approach.

The surveyed studies depict the profile of the patient who will most probably benefit from an urgent coronary angiography. The male patient at the age of 45-60 years with a history of diabetes mellitus and coronary heart disease, who has been successfully resuscitated from ventricular fibrillation and has abnormal post resuscitation ECG, but still maintains brain stem functions, is more likely to have suffered an OOHCA of primary cardiac origin.[38, 40] Such a patient should be transferred as quickly as possible to the catheterization laboratory, while the application of MTH should have already been implemented. Once again, the survival of these critically ill patients should not be separately examined, but only through a well standardized post resuscitation treatment protocol. Randomized controlled studies are urgently needed to further provide more solid evidence in selecting the most appropriate patient for this early invasive/interventional approach.

Table 1. Studies with OOHCA patients having coronary angiography and percutaneous coronary intervention (PCI)

STUDY / YEAR		CORO	PCI(%)	TIMI 2-3 (%)	SURVIVAL(%)	NEURO (%)
KAHN et al[15]	1995	11	11 (100)	7 (64)	6 (55)	4 (67)
SPAULDING et al[7]	1997	84	37 (44)	28 (76)	32 (38)	30 (94)
BULUT et al[16]	2000	10	10 (100)	8 (80)	4 (40)	3 (75)
KEELAN et al[17]	2003	15	14 (93)	14 (100)	11 (73)	9 (82)
BENDZ et al[18]	2004	40	38 (95)	38 (100)	29 (73)	N/R
LEE et al[19]	2004	37	36 (97)	32 (89)	30 (86)	25 (83)
GORJUP et al[20]	2006	117	109 (93)	102 (94)	93 (79)	74 (80)
QUINTERO et al[21]	2006	63	56 (89)	51 (91)	48 (76)	N/R
KNAFELJ et al[22]	2007	72	66 (92)	64 (97)	44 (61)	27 (61)
PLESKOT et al[23]	2007	20	19 (95)	18 (95)	15 (75)	11 (73)
GAROT et al[24]	2007	186	168 (90)	161 (96)	103 (55)	99 (96)
MARKUSOHN et al[25]	2007	25	25 (100)	22 (88)	19 (76)	17 (89)
PEELS et al[13]	2008	44	40 (91)	38 (95)	22 (50)	N/R
WOLFRUM et al[26]	2008	33	33 (100)	33 (100)	23 (70)	19 (82)
MAGER et al[27]	2008	21	20 (95)	20 (100)	17 (81)	15 (88)
LETTIERI et al[28]	2009	99	90 (91)	80 (89)	77 (78)	68 (88)
HOSMANE et al[29]	2009	78	64 (38)	62 (97)	63 (64)	58 (92)
ANYFANTAKIS et al[30]	2009	72	27 (38)	24 (89)	35 (49)	33 (94)
DUMAS et al[9]	2010	435	202 (46)	177 (88)	171 (39)	160 (94)
BATISTA et al[31]	2010	36	20 (56)	20 (100)	8 (22)	6 (75))
MOLLMANN et al[32]	2011	65	38 (58)	38 (100)	46 (71)	N/R
CRONIER et al[33]	2011	111	91 (82)	46 (51)	60 (54)	54 (90)
ZIMMERMANN et al[34]	2011	72	67 (93)	60 (90)	47 (65)	42 (89)
LIM et al[35]	2011	88	88 (100)	84 (95)	54 (61)	N/R
STROTE et al[36]	2012	61	38 (62)	38 (100)	44 (72)	34 (72)
NANJAYYA et al[37]	2012	35	23 (66)	21 (91)	18 (51)	14 (78)
CHELLY et al[47]	2012	729	347 (48)	N/R	160/347 (46)	N/R
ZANUTTINI et al[40]	2012	66	31 (47)	N/R	50/93 (54)	36/50 (72)
SIUDAK et al[39]	2012	42	40 (91)	37 (93)	37 (88)	N/R
VELDERS et al[41]	2013	224	224 (100)	N/R	187 (83.5)	168/218 (77.1)
WEISER et al[42]	2013	197	183 (93)	N/R	143 (78)	118 (64)
CALLAWAY et al[45]	2014	765	705	N/R	495 (64.7)	413 (54)
REYNOLDS et al[43]	2014	273	152 (56)	N/R	167 (61)	128 (47)
GUPTA et al[44]	2014	12,150+	12,150	11,365 (94)	9,296 (77)	N/R
GARCIA-TEJADA et al[53]	2014	84	49 (58)	N/R	61 (73)	50 (82)
TOTAL		**16,460+**	**15,311**	**12,714 (92)**	**11,715 (64)**	

CORO = coronary angiography; NEURO = (good) neurological outcome; N/R = not reported; PCI = percutaneous coronary intervention; OOHCA = out-of-hospital cardiac arrest; TIMI = Thrombolysis in Myocardial Infarction (grade flow)

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