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Comparison of Role of Early (<6 Hours) to Later (>6 Hours) or No Cardiac Catheterization Following Resuscitation From Out-of-hospital Cardiac Arrest

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Abstract

Despite reports of patients with resuscitated sudden cardiac arrest (rSCA) receiving acute cardiac catheterization, the efficacy of this strategy is largely unknown. We hypothesized that acute cardiac catheterization of patients with rSCA would improve survival to hospital discharge. A retrospective cohort of 240 patients with out-of-hospital rSCA due to ventricular tachycardia or fibrillation was identified from 11 institutions in Seattle, Washington, between 1999 and 2002. Patients were grouped into those receiving acute catheterization within 6 hours (≤ 6 hours group, $n = 61$) and into those with deferred catheterization at > 6 hours or no catheterization during the index hospitalization (>6 hours group, $n = 179$). We directed attention to survival to hospital discharge, neurologic status, extent of coronary artery disease presenting electrocardiographic (ECG) findings, and pre-arrest symptoms. Propensity score methods were used to adjust for the likelihood of receiving acute catheterization. Survival was greater in patients who underwent acute catheterization ≤ 6 hours group (72%) vs. >6 hours group (49%) ($p=0.001$). Percutaneous coronary intervention was performed in 38/61 (62%) of patients in ≤ 6 hours group, and 13/170 (7%) in > 6 hours group, $p<0.0001$. Neurologic status was similar for both groups. A significantly higher percentage of patients in the acute catheterization group had symptoms prior to cardiac arrest, and had ST-segment elevation on post-resuscitation ECG. Age, bystander cardiopulmonary resuscitation, daytime presentation, history of percutaneous coronary intervention or stroke, and acute ST elevation were all positively associated with receiving cardiac catheterization. In conclusion, in this series of patients who sustained out-of-hospital cardiac arrest, acute catheterization (within 6 hours of presentation) was associated with improved survival.

Keywords

Resuscitated out-of-hospital cardiac arrest; Ventricular Fibrillation; catheterization

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Introduction

We hypothesized that acute cardiac catheterization of patients with resuscitated sudden cardiac arrest (rSCA) would improve survival to hospital discharge. To test this hypothesis we performed a retrospective analysis on all rSCA patients who were admitted to Seattle area hospitals during a time period *before* the wide spread use of therapeutic hypothermia. We chose this earlier time frame since therapeutic hypothermia has been shown to increase survival in rSCA, which may confound the interpretation of the results. Survival and neurologic outcomes in rSCA patients who received early coronary angiography (≤ 6 hours) were compared to control groups who either did not receive coronary angiography or received angiography > 6 hours after admission to the hospital.

METHODS

This study includes 240 consecutive individuals who were resuscitated from out-of-hospital rSCA with ventricular fibrillation or tachycardia as the first identified rhythm. Upon successful resuscitation, the patients were transported to 1 of 11 receiving hospitals all but 1 with cardiac catheterization facilities. The incidents occurred between January 6, 1999 and December 15, 2002, a time period before widespread use of therapeutic hypothermia for resuscitated ventricular fibrillation patients in Seattle area hospitals.

The Seattle Fire Department's emergency medical services system, Medic One, has been previously described.¹ Variables collected for this study came from the standard Medic One screening and hospital forms and medical records review performed by the first author (JS). Demographic, medical history variables and variables describing the circumstances of cardiac arrest were obtained from either the screening or hospital forms. Medical records review was performed to obtain details of the cardiac catheterization, including timing, presence of ST segment elevation (elevation 1 mm in 2 contiguous leads, and location and extent of significant coronary artery lesions). The major independent variable of interest was whether the patient underwent cardiac catheterization performed ≤ 6 hours after hospital admission. Those who did were included in the acute cardiac catheterization or ≤ 6 hours group, whereas those who underwent the procedure at a later time or did not receive the procedure were defined as > 6 hours group.

Outcome variables obtained from the Medic I hospital form included the use of percutaneous coronary intervention (PCI), days hospitalized, hospital discharge status, and neurologic status. The primary outcome measure, hospital discharge status, was recorded on the hospital form and was defined as dead or alive. Neurologic status was determined from information in the medical record and was categorized as full recovery, mild impairment, severe impairment, or comatose.

Comparisons of characteristics of the ≤ 6 hours and > 6 hours groups were performed using the chi-square statistic for categorical variables and the 2 sample t-test for continuous measures. The decision to use acute cardiac catheterization is complex and difficult to adjust for in multivariate statistical modeling. Propensity analysis was used to control for the likelihood of an individual undergoing acute cardiac catheterization. The following variables were considered for the propensity score, with backwards stepwise logistic regression used to select the final model: age, sex, bystander cardiopulmonary resuscitation, witnessed arrest, current smoking, daytime presentation, history of smoking, myocardial infarction, congestive heart failure, hypertension, previous PCI, coronary artery bypass graft surgery, diabetes, stroke, neurologic disease, lung disease, and ST elevation on the electrocardiogram (ECG). The propensity score was categorized according to terciles and within each tercile, survival rates in ≤ 6 hours and > 6 hours groups were compared.

RESULTS

Of the 240 individuals, 25% underwent acute cardiac catheterization (≤ 6 hours group) and 75% did not (> 6 hour group). In the > 6 hours group, 43 had cardiac catheterization 6 hours after hospital admission and 136 did not undergo this procedure. Individuals in the ≤ 6 hours group were 3 years younger, and more often men, although the racial distribution was similar in the 2 groups (Table 1). With respect to medical histories, individuals in ≤ 6 hours group less often had previously recognized coronary artery disease, cardiomyopathy, arrhythmias, heart failure or stroke, and were more likely to have had a history of smoking.

Regarding the circumstances of arrest, a slightly higher proportion in the ≤ 6 hours group had acute symptoms prior to cardiac arrest. Otherwise, the distributions of initial rhythm, bystander cardiopulmonary resuscitation, witnessed arrest and daytime presentation to the hospital were not statistically different (Table 2). As expected, a higher percent of the ≤ 6 hours group had ST elevation on the admission ECG (46/61 75% vs. 36/179 20%, $p < 0.0001$). On the other hand, among those undergoing cardiac catheterization, there were no differences with respect to left main coronary artery lesions $\geq 50\%$ diameter narrowing (5% vs 2%, $p=0.48$), proximal left anterior descending artery lesions $\geq 70\%$ (28% vs. 20%, $p=0.31$), or 3 vessel disease (44% vs. 35%, $p=0.35$).

Selected outcomes in the 2 groups are shown in Table 3. A key finding was that a much higher proportion of patients in the ≤ 6 hours group were discharged alive from the hospital. Length of hospital stay was similar in the 2 groups as was the percent of patients who awakened. Neurologic status at discharge was also similar in both groups; almost 80% of survivors in each group had either full recovery or mild impairment. Last, over 60% of the ≤ 6 hours group had PCI, whereas only 30% of those who had non-acute cardiac catheterization did.

The propensity score for the likelihood of undergoing acute cardiac catheterization was calculated using the following variables from the logistic regression model of the predictors of acute cardiac catheterization: sex, daytime presentation, history of congestive heart failure, history of stroke, and ST elevation. Women as well as those with a history of congestive heart failure and/or stroke were less likely to undergo acute cardiac catheterization. Daytime presentation and ST elevation on the admission ECG were associated with a higher likelihood of undergoing the procedure. These results applied to 233 individuals (97%) with complete data.

To better understand the association between acute cardiac catheterization and survival, we compared survival in the ≤ 6 hours and > 6 hours groups for each tercile of propensity score (Table 4). Only 3 individuals in the ≤ 6 hours group appeared in the first tercile, resulting in minimal power to detect a difference in survival. In the second tercile, survival was better in the ≤ 6 hours group, but the difference was not statistically significant. In the group with highest likelihood of receiving acute cardiac catheterization, the greater rate of survival in the ≤ 6 hours group was statistically significant.

Discussion

In this series of patients who sustained out-of-hospital cardiac arrest, acute catheterization (defined as the procedure performed within the first 6 hours) was associated with improved survival in bivariate and multivariate analyses compared to the group receiving no catheterization or after 6 hours. Additionally, using propensity scoring to identify patients with a higher likelihood of receiving acute catheterization identified a sub-population of patients in which acute catheterization was greatly associated with improved survival. Most survivors in both groups were neurologically intact upon hospital discharge. Despite this

report, the rSCA patient population still presents a difficult clinical dilemma. Namely, should cardiac catheterization be regularly performed, and if so, within what time frame?

It was previously shown in an angiographic study of patients with rSCA that 94% of these patients had at least 1 epicardial coronary artery with > 70% reduction in vessel diameter.² Autopsy studies have also shown a large ischemic burden in this population. Farb et al. demonstrated that 57% of patients who succumbed to SCA had active coronary lesions (as defined by the presence of platelet and fibrin thrombi) at autopsy. This finding was present even in the absence of acute myocardial infarction. Furthermore, many patients without active coronary lesions or myocardial infarction still had epicardial coronary stenosis in excess of 70% diameter reduction.³

Given that the majority of rSCA is secondary to coronary artery disease, and that a significant number of these patients have active coronary lesions, we hypothesized and demonstrated that early catheterization and coronary intervention were associated with decreased mortality in this patient population. It has been well demonstrated that delay to coronary revascularization, whether pharmacologic⁴ or via PCI⁵ is associated with decreased survival. Despite these facts, there has been limited published research into the use of early catheterization in patients with rSCA. The majority of research has focused on patients with ST-segment elevation on the ECG after resuscitation.

The “acute catheterization” strategy was first shown to be feasible in patients with rSCA in 1995.⁶ Despite this, subsequent studies, all in patients with ST-segment elevation on post-resuscitation ECGs have reported mixed success. Bendz et al. concluded that although PCI in this population was feasible and safe, it was associated with an *increased* mortality as compared with matched patients with ST-segment elevation myocardial infarction.⁷ Furthermore, in a multivariate retrospective analysis of 186 patients with rSCA, PCI was not a predictor of 6-month survival.⁸ These studies were limited by small sample sizes. Our findings are in contrast to these and suggest a beneficial influence of early PCI.

What is the value, then, of ST-segment elevation in predicting those patients who would benefit from acute reperfusion in the rSCA setting? The presence of ST-segment elevation was a strong predictor of acute coronary occlusion in a series of 186 consecutive cases of rSCA, with an odds ratio of 4.5 for acute coronary occlusion ($p=0.004$)⁹. Presumably, these patients would be likely to benefit from acute catheterization and PCI. In a recent retrospective study from Paris¹⁰, the predictive value of ST elevation for coronary occlusion in the setting of rSCA was poor, suggesting that immediate catheterization regardless of the presence or absence of ST elevation was warranted.

If the ECG is suboptimal to detect those patients with acute coronary occlusion, what other diagnostics are available to the clinician faced with the rSCA patient? Gorjup et al correlated presenting neurologic status with outcomes of rSCA in 135 consecutive patients. While a poor presenting neurologic status predicted a poor final neurologic status, approximately 25% of initially comatose patients recovered with either no or minimal neurologic deficits.¹¹ This would argue that using neurologic status upon presentation as a determinant of which patients receive acute catheterization is not well founded.

The correlation of presenting cardiac biomarkers with acute coronary occlusion in patients with SCA is not well established. One small postmortem analysis showed that patients with cardiac death had statistically higher CK-MB than patients with non-cardiac deaths. There was also a trend toward higher troponin I in these patients, but this did not reach statistical significance.¹²

Given the relatively high frequency of acute coronary occlusions, inherent flaws in relying on the ECG for diagnosis in the rSCA patient, and imperfections in the other clinical tools usually used for diagnosis of myocardial infarction, perhaps all patients with rSCA should receive acute catheterization. Keelen et al published a long-term survival rate of greater than 60% in a series of 15 patients with rSCA and early coronary angioplasty within 8 hours. 80% of these patients had ST-segment elevation.¹³ Spaulding et al published the largest series of rSCA patients to date. Of 186 consecutive cases of rSCA, only 43% had ST-segment elevation on their post-resuscitation ECG. In this population of all-comers, successful PCI was markedly associated with survival with an odds ratio of 5.2 ($p=0.03$).⁹

Our findings suggesting improved survival with acute catheterization lend credence to the idea that all patients resuscitated from out-of-hospital ventricular fibrillation should receive early catheterization and revascularization if indicated. Our study is in agreement with a recent study, which also used a propensity-adjusted analysis that demonstrated a beneficial effect of acute catheterization following rSCA.¹⁴ The authors also pointed out that there is a bias for taking patients with better neurologic status (normal eye, verbal, and Glasgow Coma Scores) acutely for cardiac catheterization. The risk of diagnostic catheterization and coronary angiography can be considered low in these patients, and even a negative coronary angiogram would provide useful diagnostic information.

This study has several limitations. First, it is retrospective and based upon chart review. Second, selection bias is inherent in a physician's decision to perform cardiac catheterization. We have attempted to minimize such biases through the use of statistical adjustment, although we recognize biases cannot be completely eliminated with these methods. The only way to truly eliminate these biases would be to perform a randomized controlled trial of acute catheterization and PCI in this population.

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Table 1

Demographic and medical history characteristics

Variable	Group ≤ 6 hours (n=61)	Group > 6 hours or No Cath (n=179)	P value
Age (years)	64±13	67±17	0.25
Women	8 (13%)	56 (31%)	0.006
Race			0.58
White	47 (77%)	142 (79%)	
Black	6 (10%)	17 (10%)	
Native American	1 (2%)	1 (1%)	
Asian	4 (7%)	11 (6%)	
Other	1 (2%)	0 (0%)	
Unknown	2 (3%)	8 (4%)	
Coronary artery disease	14 (23%)	78 (45%)	0.002
Valvular heart disease	4 (7%)	19 (11%)	0.32
Cardiomyopathy	5 (8%)	43 (25%)	0.006
Myocardial infarction	7 (12%)	43 (25%)	0.032
Congestive heart failure	5 (8%)	54 (31%)	<0.0001
Arrhythmia	8 (13%)	62 (36%)	0.001
Hypertension	29 (48%)	80 (46%)	0.78
Hyperlipidemia	15 (25%)	57 (33%)	0.25
Coronary angioplasty	4 (7%)	17 (10%)	0.46
Coronary artery bypass grafting	5 (8%)	29 (17%)	0.11
Diabetes mellitus	8 (13%)	36 (21%)	0.20
Stroke	2 (3%)	30 (17%)	0.007
Renal failure	1 (2%)	14 (8%)	0.22
Smoker	35 (58%)	69 (40%)	0.013

* Medical history as noted in history/physical of admission note or on cardiology consult note

Table 2

Circumstances of cardiac arrest

Variable	Group \leq 6 hours (n=61)	Group > 6 hours or no Cath (n=179)	P value
Ventricular fibrillation initial rhythm	61 (100%)	173 (97%)	0.15
Acute symptoms prior to cardiac arrest	23 (38%)	42 (24%)	0.024
Bystander CPR	30 (49%)	90 (50%)	0.88
Witnessed arrest	53 (87%)	147 (82%)	0.39
Daytime presentation	49 (82%)	125 (70%)	0.12

CPR cardiopulmonary resuscitation

Table 3

Outcomes of cardiac arrest

Variable	Group ≤ 6 hours (n=61)	Group > 6 hours or No Cath (n=179)	P value
Discharged alive	44 (72%)	87 (49%)	0.001
Days hospitalized	9.1±6.0	9.8±21.7	0.81
Percutaneous coronary intervention	38 (62%)	13 (7%)	<0.0001
Awaken	40/60 (67%)	93/174 (53%)	0.08
Best neurologic status			0.30
Full recovery	18/43 (42%)	47/86 (55%)	
Mild impairment	16/43 (37%)	19/86 (22%)	
Severe impairment	4/43 (9%)	11/86 (13%)	
Comatose	5/43 (12%)	9/86 (10%)	

Table 4

Discharged alive by terciles of propensity score

Propensity score	Group ≤ 6 hours	Group > 6 hours or No Cath	P
< 0.064	1/3 (33%)	31/66 (47%)	0.64
0.065–0.21	10/13 (77%)	42/80 (52%)	0.10
> 0.21	32/44 (73%)	9/27 (33%)	0.001
Total	43/60 (72%)	82/173 (47%)	