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Coronary Angiography Predicts Improved Outcome Following Cardiac Arrest: Propensity-Adjusted Analysis

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Abstract

Introduction—Coronary angiography (CATH) is associated with survival in patients suffering out-of-hospital cardiac arrest (OHCA) from ventricular fibrillation or ventricular tachycardia (VF/VT). The effect of CATH on outcome in other cohorts is unknown. We hypothesized clinical parameters of resuscitated patients predict CATH performance and receiving CATH was associated with outcome.

Methods and Results—Chart review of resuscitated cardiac arrest patients between 2005 and 2007. Exclusion criteria included immediate withdrawal of care, hemodynamic collapse, or first neurologic exam under sedation. Clinical parameters included neurologic status (Glasgow Coma Scale- GCS), arrest location, rhythm, age, and acute ischemic ECG changes (new left bundle branch block or STEMI). Logistic regression identified clinical parameters predicting CATH. The association between CATH and good outcome (discharge home or to acute rehabilitation facility) was determined using logistic regression adjusting for likelihood of receiving CATH via propensity-adjusted score quartiles.

Of the 241 patients, mean age was 60.6 years (SD 15.9), 55% were male, 56% suffered OHCA, 39% suffered VF/VT and 40% received CATH. Significant stenosis ($\geq 70\%$) of ≥ 1 coronary arteries was identified in 69% of patients including 57% of patients without acute ischemic ECG changes. Unadjusted predictors of CATH were sex, method of arrival, OHCA, presenting rhythm, acute ischemic ECG changes, and GCS. Propensity adjusted logistic regression demonstrated an association between CATH and good outcome (OR 2.16; 95% CI 1.12, 4.19; $p < 0.02$).

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Conflict of Interest Statement

None.

Conclusion—CATH is more likely to be performed in certain patients and identifies a significant number of high-grade stenoses in this population. Receiving CATH was independently associated with good outcome.

Keywords

heart arrest; resuscitation; catheterization; ventricular fibrillation

Introduction

Cardiac arrest is a devastating clinical situation for which the odds of survival are low. Because cardiac arrest represents the most extreme form of heart failure, acute cardiac interventions may improve the odds of survival. For example, the importance of prompt coronary angiography (CATH) is well established in patients presenting with acute ischemic ECG changes such as ST-elevation MI (STEMI) or new left bundle branch block (LBBB).^{1,2,3} Delays in revascularization during acute coronary syndromes may be associated with worse outcomes.^{1,2,3} Early CATH is associated with improved survival after out-of-hospital cardiac arrest (OHCA) with pulseless ventricular rhythm (VF/VT) and/or acute ischemic ECG changes (STEMI or new left bundle branch block).⁴⁻⁷ Despite these data, there are no specific recommendations for routine performance of CATH after cardiac arrest.

Although coronary artery disease is common in patients with cardiac arrest, acute coronary syndromes may be difficult to predict by clinical criteria.⁸ Furthermore, a variety of non-cardiac variables may influence the likelihood of performing CATH in a patient after cardiac arrest.^{9, 10} In the absence of a randomized trial of CATH in the post-cardiac arrest period, rigorous analysis of observational data are required to assess the effect of CATH on good outcomes. This study examined (1) what demographic and clinical variables predict CATH after cardiac arrest and (2) whether performing CATH is associated with good outcome after adjusting for the propensity of receiving CATH. We also investigated the diagnostic and therapeutic yield of CATH.

Methods

The University of Pittsburgh Institutional Review Board approved this study. We completed a retrospective chart review of consecutive adult patients who suffered cardiac arrest (defined as receiving defibrillation or chest compressions for pulseless arrhythmia) and presented to our tertiary care facility between January 1, 2005 and December 31, 2007. We considered all patients who were successfully resuscitated from either OHCA or IHCA as potential candidates for cardiac catheterization. Contraindications included: early withdrawal of care or “comfort measures only” (CMO), first score on the Glasgow Coma Scale (GCS) obscured by a sedative or paralytic agent, planned emergent surgical intervention, or immediate re-arrest. Patients with CMO or withdrawal of care status determined within the first 6 hours were considered “early” CMO or withdrawal of care. Patients with contraindications were excluded from the analysis (Figure 1).

Demographic (age, gender, location of arrest, year of arrest, method of arrival and presenting rhythm) and clinical examination data (presence of STEMI or new LBBB, history of cardiac disease, performance of echocardiography, use of therapeutic hypothermia, and GCS) were abstracted from the medical records. Cardiac interventions (catheterization, stents placed, CABG, LVAD, transplant and intra-aortic balloon pump [IABP]) each patient received were also recorded. An occluded vessel was defined as $\geq 70\%$ lesion and a positive CATH was defined as ≥ 1 occluded vessel. Early CATH was defined as receiving CATH within 24 hours of arrival. Outcomes were classified as ‘Good’ if the patient was discharged

to home or acute rehabilitation facility. All other outcomes (discharge to chronic rehabilitation facility, skilled nursing facility, hospice or death) were classified as ‘Bad’.

Statistical Analysis

Cardiac arrest patients undergoing CATH differ from those that do not with respect to demographic and clinical characteristics. Because these same characteristics may be predictive of good clinical outcomes and patients are not randomized to receive angiography, we used a propensity score analysis to assess the association between coronary angiography and clinical outcomes.¹¹ This analysis allowed us to adjust for these potential confounders by comparing rates of good outcome between patients receiving and not receiving coronary angiography at similar levels of demographic and clinical covariates. We first used a logistic regression model that predicted early coronary angiography based on 13 demographic and clinical exam characteristics (Table 1). Demographic (age, gender, year of arrest, method of arrival, location of arrest, and presenting rhythm) and clinical examination data (presence of STEMI or new LBBB, history of cardiac disease, echocardiography, use of therapeutic hypothermia, and GCS) were included in the propensity score calculation. The c-statistic for this model was 0.89, indicating a good ability to predict patients receiving and not receiving coronary angiography. We used the predicted probability of receiving coronary angiography as the propensity score for each patient. Patients were then stratified by quartile of increasing propensity score. To verify that our propensity scores would adequately adjust for differences between those receiving and not receiving CATH, we ran logistic models predicting CATH for each of the 13 predictors of coronary angiography adjusting for the quartiles of propensity scores. Attenuation of the predictor’s adjusted odds ratio (OR) to the null value and inclusion of 1 in the confidence interval would indicate ‘effective’ propensity scores in balancing covariate differences between the two groups. As a crude stratified analysis, we then compared the rate of good clinical outcome between patients receiving and not receiving coronary angiography within each propensity score quartile using Fisher’s exact test. We then performed a multiple logistic regression to estimate the overall odds ratio of good clinical outcome for coronary angiography adjusting for propensity score quartile. In addition, we used descriptive statistics to evaluate CATH results across patients characterized by presenting rhythm. The effect of early (day of arrest) versus delayed catheterization was compared using Fisher’s Exact test. Analyses were performed using STATA version 10.0 (STATA Corporation, College Station, TX) and all tests were two-sided with $\alpha=0.05$.

The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

Of the 394 cardiac arrest subjects, 153 met exclusion criteria, primarily because of rapid re-arrest (121/153, 79%). (Figure 1) A total of 241 patients were analyzed. Clinical features of the population are listed in Table 1.

Predictors of receiving CATH

Unadjusted predictors of CATH were male gender (OR 1.71; 95% CI 1.01, 2.91), transfer from outside hospital (OR 1.94; 95% CI 1.01, 3.72), OHCA (OR 2.83; 95% CI 1.63, 4.89), PEA (OR 0.30; 95% CI 0.16, 0.58), asystole (OR 0.17; 95% CI 0.08, 0.37), unknown initial rhythm (OR 0.14; 95% CI 0.04, 0.45), STEMI or new LBBB (OR 26.25; 95% CI 8.98, 76.76), performance of echocardiography (OR 2.08; 95% CI 1.17, 3.69), abnormal eye GCS (OR 0.53; 95% CI 0.31, 0.91), abnormal verbal GCS (OR 0.23; 95% CI 0.11, 0.48), and abnormal motor GCS (OR 0.41; 95% CI 0.24, 0.69). [Table 1] There were no significant

differences between subjects with CATH and those without CATH with respect to age, year, history of cardiac disease, and use of therapeutic hypothermia. All patients with LBBB received CATH. Four of 15 STEMI patients did not receive CATH because of poor neurologic status. Adjusting for propensity score quartiles, the odds ratios of all predictors moved closer to 1.0 and their confidence intervals included the null value of 1.0, with the exception of STEMI or new LBBB (OR 4.02; 95% CI 1.12, 14.43).

Propensity score analysis: CATH and good clinical outcome

Just over half of patients receiving CATH experienced a good clinical outcome (54.2%), compared to 24.8% of patients not receiving CATH. [Table 2] The same trend in better outcomes for the CATH group was observed within propensity quartiles with the exception of the first quartile where the likelihood of receiving CATH was very small. In the overall propensity-adjusted logistic regression, receiving CATH increased the likelihood of having a good clinical outcome (OR 2.16; 95% CI 1.12, 4.19; $p < 0.02$). In exploratory analysis, early CATH (day of arrest, $n=63$) was not associated with improved survival when compared to later CATH (63% versus 67% ($n=33$), respectively; $p=0.66$), nor was it associated with good outcome (52% versus 58%; $p=0.67$).

The findings of catheterization are described in Table 3. Even in patients without acute ischemic ECG changes, CATH revealed significant coronary artery lesions in 57%. Overall, 14% of patients required IABP, 7% received CABG, 2% received LVAD, and 3% received cardiac transplant following their cardiac arrest.

Discussion

Our study demonstrates that demographic and clinical variables available immediately post-cardiac arrest are associated with CATH. Specifically, gender, OHCA, acute ischemic electrocardiographic changes, and echocardiography are positively associated with receiving CATH after cardiac arrest. An initial rhythm of PEA, asystole, or lower than maximal eye, verbal, or motor GCS are negatively associated with receipt of CATH. These data also reveal a bias for taking patients with superior neurological status to CATH. Normal eye, verbal, and motor GCS scores are independent predictors of CATH performance. Moreover, four STEMI patients in our population did not receive CATH because of unfavorable neurological status. Importantly, Levy *et al.* demonstrated that an initially poor GCS did not predict a poor neurologic outcome with certainty.¹² Prior studies have also demonstrated that the use of hypothermia after cardiac arrest improves neurologic outcome in patients who are comatose after initial resuscitation.^{13, 14} Some argue that because cardiac arrest carries a high mortality from neurological, rather than cardiac sequelae, CATH should be reserved for those patients who demonstrate neurological improvement.¹⁰ Given the priority of early reperfusion to reduce morbidity and mortality,^{1,2,3} this practice might deprive some patients who might recover neurologically of their potential survival. Furthermore, the use of therapeutic hypothermia may confound this argument, since patients may not reveal their neurological trajectory until up to several days after return of spontaneous circulation.^{12, 15} A combination of these potent therapies increased the number of patients enjoying a good outcome following cardiac arrest by 30%.⁷ These data should be considered when evaluating post-cardiac arrest patients for CATH and may prompt clinicians to consider its use in patients who may not traditionally receive it.

Even after adjusting for clinical factors associated with CATH performance, receiving CATH after cardiac arrest was independently associated with good neurological outcome following cardiac arrest. In these data, there was no difference in outcomes between groups receiving early and later CATH. This may be due to the small sample size. While it is generally accepted that early CATH is indicated in patients with STEMI or new LBBB, the

role of early CATH in other post-cardiac arrest patients remains to be determined. One potential benefit of early CATH is the ability to define coronary anatomy, since early identification of coronary versus non-coronary causes of cardiac arrest in an otherwise undifferentiated patient would result in different therapeutic strategies. Notably, 14% of the patients in this study required IABP therapy during the post-arrest period. A significant number of patients also required coronary artery bypass grafting, left ventricular assist device, or cardiac transplantation after CATH.

A criticism of prior studies investigating the use of prompt CATH to improve survival has been extensive exclusion criteria and highly selective patient populations.^{4–6, 8, 16} In this study, improved survival and outcome were associated with CATH in cardiac arrest patients regardless of arrest location, presenting rhythm, presence of STEMI or new LBBB, or neurological status. CATH was independently associated with good neurological outcome.

Finally, many patients suffering cardiac arrest have significant coronary artery disease. These data agree with prior literature suggesting 60–80% of cardiac arrests are a result of cardiovascular disease.^{4, 8, 16, 17} Those subjects without STEMI or new LBBB also had significant coronary lesions in 56–66% of cases. These data suggest the burden of coronary artery disease is high in this population and support CATH in this population. Given that CATH is independently associated with good neurologic outcome, the high coronary artery disease burden in this population, the benefits of early reperfusion, and improved therapies for brain resuscitation following cardiac arrest, CATH should be considered along with hypothermia in all post-cardiac arrest patients.

This study has several limitations. First, it is limited to a retrospective chart review. Data could have been inaccurately reported in the patient record. Patients could have been missed, but we believe this to have been minimized by our inclusive search strategy. Third, the cohort of IHCA patients may not be representative of other hospitals, since ours has a tiered Rapid Response System with a reduced rate of IHCA.¹⁸ Finally, the outcome assessed was discharge to home or acute rehabilitation facility as a surrogate for long-term neurological status.

Conclusions

Demographic and clinical variables, including neurologic exam, predict performance of CATH after cardiac arrest. When adjusted for these variables, performance of CATH is independently predictive of good neurological outcome. Post-cardiac arrest CATH reveals a high incidence of significant coronary artery disease.

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Figure 1.

Flowchart of patients with cardiac arrest from 2005 to 2007. A good outcome was defined as discharge to the patient's home or to an acute rehabilitation center.

Table 1

Patient characteristics predicting CATH performance.

Characteristics	n (%)	n (%) Performance of CATH		P-value	OR for Performing CATH (95%CI)	
		All cases 241 (100%)	Yes (n=96)		No (n=145)	Unadjusted
Demographics						
Age (Years)				0.664		
Mean ± standard deviation	60.6 ± 15.9	61.2 ± 13.9	60.3 ± 16.6		1.0 (0.99, 1.02)	0.99 (0.98, 1.02)
Gender				0.044		
Female	107 (45%)	35 (37%)	72 (50%)		1	1
Male	134 (55%)	61 (64%)	73 (50%)		1.71 (1.01, 2.91)	1.18 (0.61, 2.25)
Year of Arrest				0.375		
2005	69 (29%)	23 (24%)	46 (32%)		1	1
2006	91 (38%)	37 (39%)	54 (37%)		1.37 (0.71, 2.63)	0.84 (0.37, 1.91)
2007	81 (34%)	36 (38%)	45 (31%)		1.6 (0.82, 3.11)	1.00 (0.43, 2.31)
Method of Arrival				< 0.001		
EMS	59 (24%)	25 (26%)	34 (23%)		1	1
Transfer from outside hospital	102 (42%)	60 (63%)	42 (29%)		1.94 (1.01, 3.72)	1.54 (0.73, 3.27)
Inpatient	75 (31%)	9 (9%)	66 (46%)		0.19 (0.07, 0.44)	0.53 (0.19, 1.50)
In ED	5 (2%)	2 (2%)	3 (2%)		0.91 (0.14, 5.83)	0.91 (0.12, 6.89)
OHCA				< 0.001		
Yes	135 (56%)	68 (71%)	67 (46%)		2.83 (1.63, 4.89)	1.34 (0.68, 2.65)
No	106 (44%)	28 (29%)	78 (54%)		1	1
Presenting Rhythm				< 0.001		
VF/VT	93 (39%)	57 (60%)	36 (25%)		1	1
PEA	74 (31%)	24 (25%)	50 (34%)		0.30 (0.16, 0.58)	0.66 (0.31, 1.43)
Asystole	52 (22%)	11 (11%)	41 (28%)		0.17 (0.08, 0.37)	0.69 (0.26, 1.82)
Unknown	22 (9%)	4 (4%)	18 (12%)		0.14 (0.04, 0.45)	0.59 (0.15, 2.25)
Clinical Exam						
STEMI or new LBBB				< 0.001		
Yes (either)	46 (20%)	42 (44%)	4 (3%)		26.25 (8.98, 76.76)	4.02 (1.12, 14.43)
No (neither)	189 (78%)	54 (56%)	135 (97%)		1	1
History of Cardiac Disease				0.526		

Characteristics	n (%)	n (%) Performance of CATH		P-value	OR for Performing CATH (95%CI)	
		All cases 241 (100%)	Yes (n=96)		Unadjusted	Adjusted for Propensity score
Yes	122 (51%)		46(49%)		0.84 (0.50, 1.42)	0.91 (0.47, 1.76)
No/unknown	115 (49%)		48(51%)		1	1
Echocardiography						
Yes	160 (66%)		73 (76%)	0.012	2.08 (1.17, 3.69)	1.64 (0.78, 3.37)
No	80 (33%)		23 (24%)		1	1
Therapeutic Hypothermia				0.882		
Yes	79 (33%)		32 (33%)		1.04 (0.60, 1.80)	0.88 (0.45, 1.73)
No	162 (67%)		64 (67%)		1	1
Eye GCS				0.020		
1-3	152 (63%)		52 (54%)		0.53 (0.31, 0.91)	0.84 (0.43, 1.63)
4	89 (37%)		44 (46%)		1	1
Verbal GCS				<0.001		
1-4	202 (84%)		69 (72%)		0.23 (0.11, 0.48)	0.65 (0.28, 1.51)
5	39 (16%)		27 (28%)		1	1
Motor GCS				0.001		
1-5	151 (63%)		48 (50%)		0.41 (0.24, 0.69)	0.61 (0.31, 1.18)
6	90 (37%)		48 (50%)		1	1

EMS: Emergency Medical Services. **In ED:** Cardiac arrest occurred in the Emergency Department.

OHCA: Out-of-hospital cardiac arrest.

VF: Ventricular fibrillation.

VT: Ventricular tachycardia.

STEMI: ST-segment elevation myocardial infarction. **LBBB:** new left bundle branch block

GCS: Glasgow Coma Score

Table 2

Comparison of the percentage with good clinical outcome for patients who received CATH and those who did not

	% Good Outcome		p-value
	*CATH	No CATH	
Overall unadjusted	52/96 (54.2%)	36/145 (24.8%)	<0.0001
Quartiles of Propensity Score			
First quartile	0/1 (0%)	8/57 (14%)	1.0
Second quartile	6/16 (38%)	13/42 (31%)	0.7
Third quartile	15/25 (60%)	10/33 (30%)	0.03
Fourth quartile	31/54 (57%)	5/13 (38%)	0.3

CATH: Cardiac catheterization with coronary angiography.

Table 3

Table 3A. Catheterization results in patients with ECG changes of STEMI or new LBBB.					
	All Rhythms (n=46)	VF/VT (n=27)	PEA (n=11)	Asystole (n=7)	Unknown (n=1)
Received CATH	42 (91%)	27 (100%)	8 (73%)	6 (86%)	1 (100%)
Among those receiving CATH					
Positive CATH	39 (93%)	25 (93%)	7 (88%)	6 (100%)	1 (100%)
1 vessel	16 (38%)	13 (48%)	1 (13%)	2 (33%)	0 (0%)
2 vessels	11 (26%)	6 (22%)	3 (38%)	2 (33%)	0 (0%)
3 vessels	7 (17%)	4 (15%)	1 (13%)	2 (33%)	0 (0%)
4 vessels	3 (7%)	0 (0%)	2 (25%)	0 (0%)	1 (100%)
5 vessels	2 (5%)	2 (7%)	0 (0%)	0 (0%)	0 (0%)
Stent	29 (63%)	21 (78%)	4 (36%)	3 (43%)	1 (100%)
CABG	5 (11%)	4 (15%)	1 (9%)	0 (0%)	0 (0%)
LVAD	2 (4%)	0 (0%)	1 (9%)	0 (0%)	1 (100%)
Transplant	2 (4%)	0 (0%)	2 (18%)	0 (0%)	0 (0%)
IABP	16 (35%)	6 (22%)	5 (45%)	4 (57%)	1 (100%)
Table 3B. Catheterization results in patients without ECG changes of STEMI or new LBBB.					
	All Rhythms (n=195)	VF/VT (n=66)	PEA (n=63)	Asystole (n=45)	Unknown (n=21)
Received CATH	54 (28%)	30 (45%)	16 (25%)	5 (11%)	3 (14%)
Among those receiving CATH					
Positive CATH	31 (57%)	17 (57%)	9 (56%)	3 (60%)	2 (66%)
1 vessel					
2 vessels	13 (24%)	8 (27%)	3 (19%)	2 (40%)	0 (0%)
3 vessels	7 (13%)	2 (7%)	3 (19%)	0 (0%)	2 (66%)
4 vessels	5 (9%)	3 (10%)	1 (6%)	1 (20%)	0 (0%)
5 vessels	4 (7%)	3 (10%)	1 (6%)	0 (0%)	0 (0%)
	2 (4%)	1 (3%)	1 (6%)	0 (0%)	0 (0%)
Stent	19 (10%)	10 (16%)	5 (9%)	1 (2%)	3 (15%)
CABG	11 (6%)	9 (14%)	1 (2%)	1 (2%)	0 (0%)
LVAD	4 (2%)	2 (3%)	1 (2%)	1 (2%)	0 (0%)

Table 3A. Catheterization results in patients with ECG changes of STEMI or new LBBB.

	All Rhythms (n=46)	VF/VT (n=27)	PEA (n=11)	Asystole (n=7)	Unknown (n=1)
Transplant	6 (3%)	5 (8%)	0 (0%)	1 (2%)	0 (0%)
IABP	18 (10%)	11 (17%)	3 (5%)	3 (7%)	2 (10%)

CATH: Cardiac catheterization with coronary angiography. **Positive CATH:** lesion $\geq 70\%$ present on CATH. **CABG:** Coronary artery bypass graft. **LVAD:** Mechanical left-ventricular assist device. **IABP:** Intra-aortic balloon pump. **VF/VT:** Ventricular fibrillation or ventricular tachycardia. **PEA:** Pulseless electrical activity.