SIGNA VITAE 2010; 5 (Suppl 1): 55 - 59

Establishing Coronary Patency: A Key to Optimal Post Resuscitation Care

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ABSTRACT

The formalizing post resuscitation care to include therapeutic hypothermia and cardiac angiography with percutaneous coronary intervention when needed could significantly improve survival following cardiac arrest. Any sudden death patient suspected to have a cardiac origin for their cardiac arrest should be considered for early catheterization and subsequent percutaneous coronary intervention (PCI) if a culprit lesion can be identified. Successful PCI improves survival to hospital discharge and cerebral performance category in patients with or without ST elevation. Current 'report carding' methodology needs to be changed regarding those resuscitated from cardiac arrest (patients with cardiac arrest not including them in any statistical reporting on PCI mortality report cards).

Key words: percutaneous coronary intervention, hypothermia, cardiac arrest, survival to hospital discharge, cerebral performance category, PCI report carding

Introduction

Recent changes in several community resuscitation programs have resulted in improved outcomes. (1-4) Such changes have emphasized chest compression-only bystander basic life support and a renewed emphasis on uninterrupted, forceful chest compressions during professionally-performed cardiopulmonary resuscitation (CPR). During this same period the importance of aggressive post resuscitation care has been recognized. Investigators in Norway documented that simply formalizing post resuscitation care to include therapeutic hypothermia and cardiac angiography with percutaneous coronary intervention when needed could significantly improve one year survival following cardiac arrest. (5) Sunde et al. found an historical post-resuscitation mortality rate of 74% at their hospital. They began a program of formalized in-hospital post-resuscitation care, including the use of mild (32-34 °C) therapeutic hypothermia and early cardiac catheterization with percutaneous coronary intervention (PCI) for appropriate lesions. After instituting this more aggressive post-resuscitation care their one-year survival rate increased to 56%. Most impressively, more than 90% of those who survived had a cerebral performance category (CPC) score of 1, signifying normal, intact neurological function. Multi-variant analysis revealed that the most powerful aspect of their new post resuscitation care protocol was reperfusion therapy, with an adjusted odds ratio of 4.5. Of note, the decision to perform cardiac catheterization post resuscitation was ultimately left to the treating physician based on the likelihood of a cardiac etiology for the cardiac arrest.

Post Resuscitation Coronary Angiography and Intervention

The success of this more formalized and aggressive post resuscitation care approach spawned a number of important questions regarding early catheterization and PCI after cardiac arrest, namely 1) who should undergo such, 2) when should it be done, and 3) does it truly improve outcome? Many interventional cardiologists are currently reluctant to perform coronary angiography and subsequent intervention on those with altered states of consciousness post cardiac arrest fearing long-term central nervous system disability. They believe that an aggressive invasive approach would be inappropriate for those with permanent central nervous system damage. Hence, they argue for a period of cautious waiting until the neurological prognosis can be established. Unfortunately, it has also been shown that such neurological prognostication during the first 24 or even 48 hours after resuscitation from cardiac arrest is difficult and unreliable. (6) Waiting for such declaration of long-term neurological recovery compromises the opportunity to intervene and alter that same recovery, both neurologically and cardiac-wise. Alternatively some have had the courage to take the post resuscitated to the catheteriza-

tion laboratory and have reported their experiences.

Investigators in Paris were the first to report on their experience in performing early catheterization and PCI in patients successfully resuscitated from out-of-hospital cardiac arrest. Spaulding et al. reported on 84 patients successfully resuscitated after out-of-hospital cardiac arrest who underwent early coronary angiography and, when indicated, percutaneous coronary intervention. (7) Seventy-one percent were found to have clinically significant coronary artery disease, including nearly 50% who had total occlusion on cardiac catheterization. These authors noted, "Clinical and electrocardiographic findings such as chest pain and/or ST elevation on the ECG were poor predictors of acute coronary occlusion". In their experience 11% of patients with an acutely occluded coronary had no evidence of ST elevation on their post-resuscitation neither ECG nor chest pain prior to their cardiac arrest. These data suggest that ST segment elevation on the post resuscitation ECG is not a failsafe method of identifying those with an acute coronary occlusion as the cause of their out-of-hospital cardiac arrest.

These same investigators just reported an updated experience in the current era (2003-2008) of stent-based PCI. (8) Over this 5 year period, 435 patients resuscitated from out-of-hospital cardiac arrest (without obvious extracardiac cause) underwent immediate coronary angiography at admission. Thirty-one percent (134) had ST elevation on their post resuscitation electrocardiogram, while 69% (301) had no ST elevation. Many of the latter had some ECG abnormalities including ST depression (127/301), conduction abnormalities (87/301) and nonspecific changes (40/301), while some had no abnormalities at all (47/301). The incidence of ventricular fibrillation (VF) among those with and without ST elevation was similar (72% vs 66%; p = 0.28). Overall survival to hospital discharge occurred in 171/435 (39%), with the vast proportional of survivors being neurologically-intact (CPC 1 or 2) in 160/171 (94%). Outcome was similar in ST elevation group and those without ST elevation, and was influenced by successful reperfusion at PCI rather than the presence or absence of ST elevation. Indeed, multivariable analysis showed successful PCI to be an independent predictor of survival, regardless of the post resuscitation ECG ST segment pattern. The authors concluded that immediate cardiac angiography and PCI provides a survival benefit in selected patients resuscitated from out-of-hospital cardiac arrest without an obvious non-cardiac etiology.

ST Segment Elevation MI and Cardiac Arrest

The subgroup most commonly studied for immediate catheterization and PCI after cardiac arrest are those with ST elevation on their post resuscitation electrocardiogram. Though rarely included in the randomized trials of ST elevation myocardial infarction (STEMI) treatments, these patients are generally treated clinically similar to STEMI patients not experiencing cardiac arrest, i.e. with attempts to provide early reperfusion therapy. A number of reports have recently appeared examining the strategy of early catheterization and angioplasty for resuscitated victims of out-of-hospital cardiac arrest secondary to an acute ST elevation MI (ST elevation on their ECG). Gorjup et al. reported on 135 STEMI-patients, who suffered cardiac arrest and were resuscitated from 2000-2005. (9) Catheterization was performed in each, and PCI where indicated, resulting in a survival to hospital discharge rate of 67%. They noted that patients who were resuscitated from cardiac arrest and conscious at the time of catheterization and angioplasty had the same good outcomes as those STEMI patients who never suffered cardiac arrest. However, patients who were comatose post resuscitation at the time of their catheterization had a decreased survival rate of only 51%. Garot et al. reported on a series of 186 ST elevation myucardial infarction (MI) patients resuscitated from cardiac arrest, who subsequently underwent coronary angiography and angioplasty. (10) Fifty-five percent of this group survived to hospital discharge. Eighty-six percent of these survivors were neurologically intact with the CPC score of 1. Hosmane et al. recently reported on the largest series from the USA, involving 98 ST-elevation MI patients, who suffered cardiac arrest and were resuscitated between 2002-2006l. (11) These investigators reported a 64% survival-to-hospital discharge rate, with 92% of survivors achieving a full neurological recovery. According to their initial neurological function post-resuscitation, those who were alert and awake had a 96% survival-to-discharge rate and 100% of survivors were neurologically intact. Those minimally responsive had a 93% survival-to-discharge rate, and 76% remained neurologically intact. Those who were unresponsive at the time of catheterization and angioplasty had a 44% survival to discharge rate, with 88% of survivors emerging neurologically intact. These authors concluded that "serious consideration should be given to emergent angiography and revascularization, regardless of initial post-resuscitation neurologic status". Among the 59 patients who were initially unresponsive post-resuscitation, 40 had acute coronary angiography and 33 underwent percutaneous coronary intervention. Eighteen of the 33 (55%) survived to hospital discharge, with 89% of them remaining neurologically intact.

The literature contains 18 reports totaling 1,395 patients resuscitated from cardiac arrest, who have undergone early cardiac catheterization with revascularization when appropriate ('4-20'). Fifty-two percent (727/1,395) of these post-resuscitation patients survived to hospital discharge (table 1). Among those who survived, 89% (504/567) were neurologically intact. This includes both conscious and comatose patients upon their arrival at the coronary angiographic suite. Though all of these reports are non-randomized case series, this summary data is impressive

Table 1. STEMI Patients Post Resuscitation Receiving Early Cath and PCI.

Author/Date	Surv to DC	Good Neuro among Surv
Kahn 1995	6/11	4/6
Spaulding 1997	32/84	30/32
Lin 1998	9/10	NA
Bulut 2000	4/10	NA
Borger van der Berg 2003	39/42	NA
Keelan 2003	11/15	9/11
Bendz 2004	29/40	NA
Quintero-Moran 2006	18/27	NA
Gorjup 2007	90/135	72/90
Garot 2007	102/186	88/102
Richling 2007	24/46	22/24
Markusohn 2007	19/25	17/19
Werling 2007	9/13	NA
Pleskot 2008	14/20	11/14
Hosmane 2009	63/98	58/63
Anyfantakis 2009	35/72	33/35
Reynolds 2009	52/96	NA
Dumas 2010	171/435	160/171
Totals: 18 reports; n= 1,395 pts		
727/1,395 (52%)	504/567 (89%)*	

* = pts were either conscious or comatose

DC, hospital discharge; NA, not avaiable; PCI, percutaneous coronary intervention; STEMI, ST elevation myocardial infarction.

Table 2. Post Resuscitation Patients Receiving Both Hypothermia and PCI.

Author/Date	Survival to DC	Good Neuro among Survivors
Hovdenes 2007	41/50	24/41
Knafelji 2007	30/40	22/30
Wolfrum 2008	12/16	11/12
Peels 2008	22/44	NA
Batisa XXXX	8/20	6/8
Totals: 5 reports; n= 170 pts		
113/170 (66%)	73/91 (80%)*	

* = all pts were comatose post resuscitation

DC, hospital discharge; NA, not avaiable.

and clearly better than historical control data of a 25% survival to hospital discharge rate, when early catheterization and PCI are not utilized.

Combining Early Angiography, PCI, and Therapeutic Hypothermia

The most successful strategy for improving long-term survival after successful resuscitation is combining an early invasive/interventional approach with mild therapeutic hypothermia. Five non-randomized case series have been reported, involving a total of 170 STEMI patients, who post resuscitation remained comatose and were treated with both therapeutic hypothermia and early coronary intervention. (12-16) Sixty-six percent (113/170) survived to hospital discharge, with 80% (73/91) of survivors having intact neurological function (table 2).

The Resuscitated Patient without ST Elevation on their ECG

The data for rapid induction of mild hypothermia combined with emergent coronary angiography and PCI is convincing for STEMI patients successfully resuscitated from cardiac arrest. But, what if the post-resuscitation electrocardiogram does not exhibit ST elevation? Eleven percent of post-resuscitation patients with an acute coronary occlusion will not have ST elevation on their ECG. (7) The question then arises, should all patients remaining comatose after resuscitation from out-of-hospital cardiac arrest have emergent coronary angiography combined with therapeutic hypothermia? Anyfantakis et al. published a series of 72 consecutive out-of-hospital cardiac arrest survivors who underwent urgent cardiac catheterization, without regard to the length of time it took to resuscitate, their precedent clinical complaints, or their post-resuscitation electrocardiographic findings. (17) Thirty-eight percent had angiographic findings compatible with an acute coronary syndrome, either having acute occlusion or irregular and unstable lesions suggestive of ruptured

plaque with thrombus. They found that ST segment elevation on the 12-lead post-resuscitation ECG had a positive predictive value of 95% for the identification of significant angiographic coronary disease, but its negative predictive value was only 44%. This suggests that the lack of ST elevation on the post-resuscitation 12-lead ECG is not a reliable predictor of not having acute coronary disease. Similarly, Spaulding and colleagues in Paris found similar values in their recently updated experience with a positive predictive value of 96% for the identification of significant angiographic coronary disease, but a negative predictive value was only 44%. Our experience at the University of Arizona, reported recently in Catheterization and Cardiovascular Interventions (18) has led us to offer coronary angiography and possible PCI to all victims of cardiac arrest who have successfully resuscitated regardless of their ECG findings. In our five cases, none had ST elevation post resuscitation. Two had acutely occluded vessels, one had an unstable and high grade culprit lesion, and two had no coronary arterial disease (CAD). One of these without coronary disease had a significant coronary anomaly and the other a severe hypertensive cardiomyopathy. If such patients are comatose at the time of coronary angiography, we induce mild therapeutic hypothermia simultaneously with the angiography and percutaneous coronary intervention. Though some would disagree, (19) this same approach now recommended by Spaulding and co-workers in Paris, (8) as well as White and McMullen at Ochsner Clinic in New Orleans. (20)

PCI Report Carding for Post Resuscitation Patients

This 50 to 66%% survival rate is encouraging and double the historical control rate of 25%, nonetheless nearly half of these high risk patients will die in the hospital. According to currently accepted definitions used for inter-hospital comparisons such hospital deaths are tabulated as a catheterization or interventional death, since the patient had a coronary angiogram or PCI upon entry into the hospital. (21) Such a classification system discourages physicians and interventional centers from considering early catheterization and intervention in post resuscitated patients. An editorial in Catheterization and Cardiovascular Interventions by McMullan and White calls for a change in these common outcome reporting systems. (20) These well known interventionalists note that mounting evidence suggests that mild therapeutic hypothermia combined with early catheterization and possible PCI should be adopted as a systematic strategy for post cardiac arrest patients. These authors ask in their editorial why then the reluctance among both interventional cardiologists and medical centers to provide such for post cardiac arrest patients? "What are the obstacles? The first is a persistent perception that cardiac arrest survivors have near-hopeless prognosis". The literature shows this simply is not true in 2010. The authors of this editorial suggest that "such perceptions can be changed by educating both health care providers and hospital administrators". The second main reason for the current reluctance among some is the current enthusiasm for procedural 'Score Carding'. The original intention for score carding was to provide physician and institutional accountability. The unintended consequence can be the avoidance of performing appropriate procedures for risk patients. This is certainly true at times for the post cardiac arrest patient. Emergent percutaneous coronary intervention in such post cardiac arrest patients should be categorized as 'compassionate use' PCI and subsequent outcomes not included in overall PCI mortality calculations. Hospitals which excel in providing mild therapeutic hypothermia and early intervention for post cardiac arrest patients should be highlighted as 'centers of excellence' "not labeled as poor performers by current score card reporting methodology". (20) Post-resuscitation patients are one of the highest risk subgroups undergoing coronary intervention and should be recognized as such and PCI operators and centers encouraged to do that which is best for the patient, not avoid such therapy because of fear concerning individual operator and institutional mortality statistics.

Conclusions

Aggressive post resuscitation care is crucial in improving long-term survival among those suffering cardiac arrest. Restoration of a pulse and blood pressure are the beginning not the end. The use of therapeutic hypothermia combined with early coronary angiography and PCI in resuscitated patients can result in remarkable survival with intact neurological function. Any sudden death patient suspected to have a cardiac origin for their cardiac arrest should be considered for early catheterization and subsequent PCI if a culprit lesion can be identified. Successful percutaneous coronary intervention improves survival to hospital discharge in patients with or without ST elevation. It is now clear that establishing coronary patency in a key to optimal post resuscitation care. Current 'report carding' methodology needs to be changed regarding those resuscitated from cardiac arrest. Individual PCI operators and institutions should not be penalized for their efforts in behalf of this unique and high risk subgroup of patients. One possibility would be to consider the use of PCI for such patients as "compassionate use", thereby not including them in any statistical reporting on PCI mortality report cards.

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