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REVIEW ARTICLE

The Role of Coronary Catheterization Laboratory in Post-Resuscitation Care of Patients Without ST Elevation Myocardial Infarction

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Abstract: ***Background*:** Out of hospital cardiac arrest management of patients with non-ST myocardial infarction per current American Heart Association and European Resuscitation Council guidelines leave the decision in regard to early angiography up to the physician operators. Guidelines are clear on the positive impact of early intervention on survival and improvement on left ventricular function in patients presenting with cardiac arrest and ST elevation myocardial infarction on electrocardiogram. This review aims to analyze the data that current guidelines are based upon in regards to out of hospital cardiac arrest with electrocardiogram findings of non-ST elevation myocardial infarction as well as review of other clinical trials that support early angiography and reperfusion strategies.

***Conclusion*:** Analysis of current literature shows that early coronary evaluation in patients with no finding of ST elevation on ECG can help improve survival in patients suffering out of hospital cardiac arrest.

Keywords: Cardiac arrest, non ST elevation myocardial infarction, cardiac catheterization, angiography, electrocardiogram.

1. INTRODUCTION

The role of coronary catheterization and percutaneous coronary intervention of culprit lesions in patients with Out-of Hospital Cardiac Arrest (OHCA) and subsequent electrocardiogram (ECG) showing ST-Segment Elevation Myocardial Infarction (STEMI) has been widely studied through multiple meta-analysis and is now part of the guidelines for post-resuscitation care as per the 2015 American Heart Association (AHA) Guidelines for Cardiopulmonary Resuscitation and Emergency Care 2015 [1]. Cardiac origin remains the most common cause of OHCA with Acute Coronary Syndromes (ACS) STEMI and non-ST Elevation Myocardial Infarction (NSTEMI) compromising the majority of cases. While the cardiac catheterization is well defined for STEMI by both the American Heart Association 2015 Guidelines along with the European Resuscitation Council Guidelines for Resuscitation 2015 [2], the role of the cardiac catheterization remains less well defined in cases of cardiac arrest and NSTEMI on ECG. Data points to a potentially significant role of cardiac catheterization laboratory in patients with NSTEMI [3, 4] as almost one-third of patients have acute lesions that can be potential revascularization targets through emergent and early percutaneous coronary interventions.

2. CASE PRESENTATION

A 65 year-old male with no previous pertinent medical history presented to the University of Arizona Medical Center after a fall from a horse, feeling symptoms of dizziness prior to the event. Patient was evaluated by Emergency Medical Services (EMS) within 10 minutes of event, and found to be in Pulseless Electrical Activity (PEA) after which Cardiopulmonary Resuscitation (CPR) was begun. Upon arrival to the emergency room, the patient received a total of 34 minutes of CPR. Patient's rhythm on telemetry changed from PEA to ventricular fibrillation, with subsequent electrical shock converted the rhythm to sinus tachycardia. The patient was then intubated and a 12 lead ECG was performed that showed no ST elevations. Hypothermia protocol was initiated and the patient was taken urgently to the coronary catheterization laboratory. Cardiac catheterization revealed 3 vessel disease. An acute lesion within the right coronary artery was ballooned and ensuing drug-eluting stent deployed. The left circumflex coronary artery had a 70% lesion which was stented with a drug-eluting stent. The left anterior descending artery had a 70% lesion proximally and gave a large diagonal branch. This lesion was also stented with a drug-eluting stent (Figs. **1-4**). The patient began to regain consciousness after two days of rewarming. Post-resuscitation was complicated by atrial fibrillation for which patient was started on amiodarone and therapeutic anticoagulation. Patient was discharged within 15 days from presentation of out of hospital cardiac arrest. The survival of this patient and other patients who suffer out of hospital cardiac arrest is dependent on a variety of factors including prompt administration of bystander and EMS CPR, initiation of hypothermia protocol and prompt coronary intervention regardless of ECG findings.

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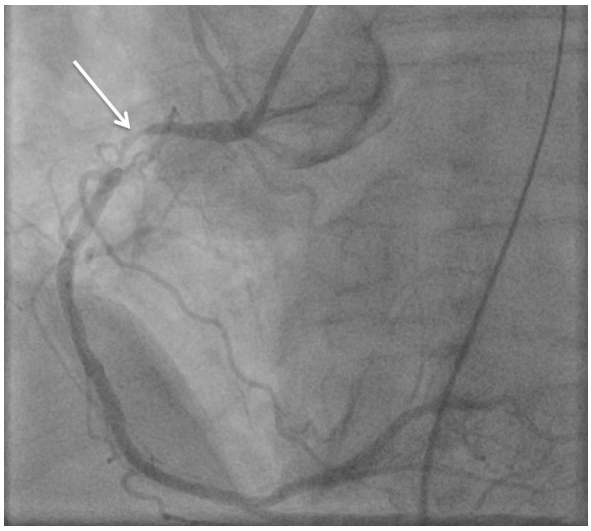

Fig. (1). Angiogram of left coronary system with left anterior descending artery lesions (solid arrow) and left circumflex coronary artery (dashed arrow).

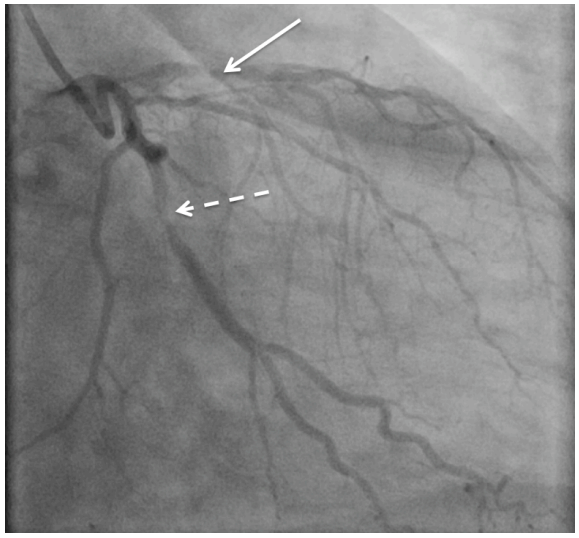

Fig. (2). Angiogram of right coronary artery (solid arrow).

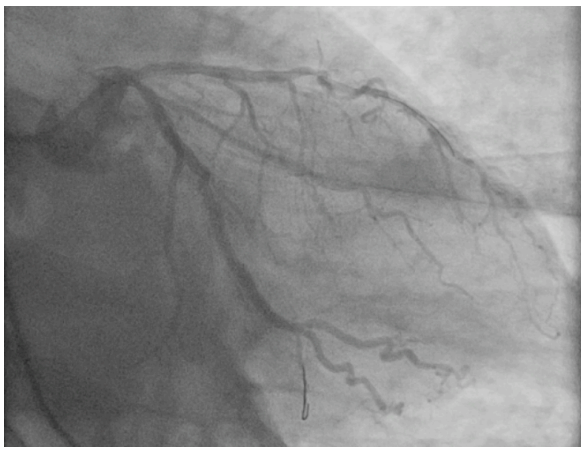

Fig. (3). Angiogram of the left coronary system after stenting of the left anterior descending artery lesions and left circumflex coronary artery.

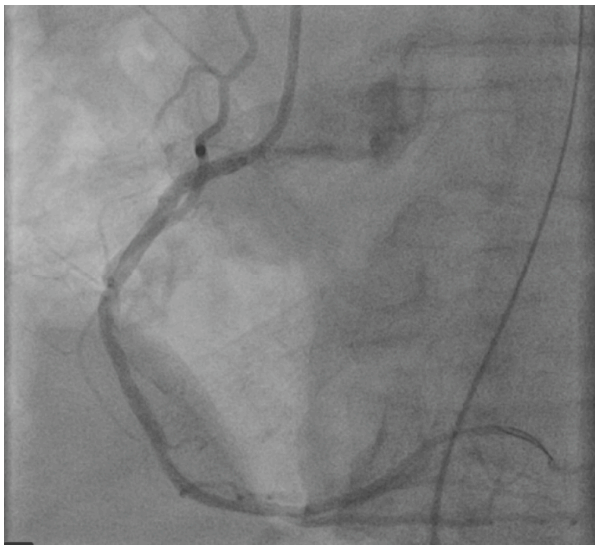

Fig. (4). Angiogram of right coronary artery after stenting.

3. CURRENT GUIDELINES

Both the 2015 European Resuscitation Council (ERC) Guidelines for Resuscitation 2 and the 2015 AHA Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care1 are in agreement for post-cardiac arrest patients in instances of STEMI and NSTEMI (Table **1**). As per the guidelines, in cases of arrest suspected due to STEMI recommendations remain for emergent coronary angiography (Class I, LOE B) while in cases of NSTEMI emergent angiography is a reasonable recommendation (Class IIa, LOE B) based on patient risk factors and likelihood of coronary involvement [1]. These factors include analysis of risk scores (HEART, GRACE, TIMI Scores), comorbid conditions, dynamic ECG changes and ST depressions in the absence of STEMI, hemodynamic monitoring, and symptoms prior to and on presentation [1, 2].

4. EVIDENCE FOR CURRENT GUIDELINES:

Current guidelines for ERC and AHA are supported by evidence from two landmark trials in which cardiac catheterization in patients without STEMI was shown to help improve survival in patients with presenting symptoms of cardiac arrest [1, 2]. The aim of the study conducted by Hollenbeck *et al*, published in Resuscitation in 2014, was to evaluate if early invasive strategy in this subset of patients showed improved survival outcomes [5]. 754 patients were initially evaluated for either STEMI or NSTEMI with concurrent cardiac arrest. Patients presenting with STEMI were excluded from analysis. A total of 269 patients presenting with ventricular tachycardia or ventricular fibrillation in a comatose state following arrest were analyzed and divided into early or no early coronary cardiac catheterization subsets defined as an early invasive strategy on admission or during the time period in which hypothermia was initiated and late invasive at any time afterwards in the hospitalization beyond 24 hours from presentation. 122 patients were included in the early catheterization group and 147 in the late catheterization group. Within the subset of patients analyzed with NSTEMI, culprit acute coronary occlusions were seen in 26.2% of pa-

Table 1. Percentage of patients with culprit lesions presenting with out of hospital cardiac arrest and non-ST elevation myocardial infarction.

Author	Year	Patients with NSTEMI	Patients with Culprit Lesion and NSTEMI	Percentage of Patients with Culprit Lesion
Millin *et al*. [4]	2016	1159	273	32.2
Hollenbeck *et al*. [5]	2014	163	44	27
Bro-Jepssen *et al*. [6]	2012	82	43	52
Kern *et al*. [7]	2015	247	82	32.2
Wilson *et al*. [8]	2017	97	24	24.7
Merchant *et al*. [8]	2008	17	10	80
Dumas *et al*. [10]	2010	301	176	56
Spaulding *et al*. [12]	1997	85	9	11
Radsel *et al*. [13]	2011	54	20	36
Anyfantaskis *et al*. [14]	2009	44	8	17
Gupta *et al*. [15]	2014	891	2775	32

tients in early cardiac catheterization group versus 29.3% in the late cardiac catheterization group (p=0.381). Within both groups, rates of percutaneous coronary intervention remained the same between the two groups at 32.8% and 39.0% respectively (p=0.628). Survival rate for patients treated with an early cardiac catheterization strategy was 65.6% versus late cardiac catheterization 48.6% (p=0.017). In addition, improved neurological outcomes were seen in patients treated with early cardiac catheterization strategy as scored per Cerebral Performance Category (CPC) scores, 60.7% in early cardiac catheterization and 48.6% in late subsets (p=0.17). Acute coronary occlusions including both culprit and non-culprit lesions in both early and late subgroups were seen in 27.0% of patients. Culprit lesions defined as occlusion over 70% were seen in 39/122 patients in the early catheterization subgroup, 32.0% and 16/41 in the late catheterization group, 39%.

As a result of the data presented by Hollenbeck *et al*, it can be seen that early cardiac catheterization is shown to improve survival in patients with out of hospital cardiac arrest due to ventricular fibrillation or ventricular tachycardia and non-ST Elevation Myocardial Infarction5. While results of this study are positive and look favorably upon the role of early coronary angiography, Hollenbeck *et al*. stress the importance of 'chain of survival' in providing a critical role in patients presenting with cardiac arrest [5]. This includes early recognition, initiation of cardiopulmonary resuscitation and early electrical defibrillation with appropriate notification of emergency personnel to transport patients to facilities capable of performing angiography. While intervention after identification of NSTEMI in cardiac arrest patients showed improved survival and neurological function, authors of this study posit that the role of mechanical support such as intra-aortic balloon pumps and impeller devices, treatment of hypotension with vasopressor therapy and anticoagulant therapy in patients anticipated to undergo angiography cannot be understated. The increased interventions associated with taking a patient to cardiac catheterization laboratory may play a role in the improved survival in these patients, exclusive of revascularization within the coronary catheterization laboratory. Within the subgroup analysis of patients undergoing early reperfusion strategy, approximately a third of patients were identified with culprit lesions requiring intervention, further providing evidence for the role of early angiography in patients who present without ST elevation on ECG.

The second original research paper cited by both AHA and ERC guidelines [1, 2] was published by Bro-Jeppesen *et al*. in the European Heart Journal: Acute Cardiovascular Care in 2012 [6]. This study aimed to evaluate the use of coronary angiography in patients with out of hospital cardiac arrest and evaluate long-term and short-term survival statistics in patients undergoing emergency coronary angiography (CAG) defined as cardiac catheterization within 12 hours of presentation after out of hospital cardiac arrest. Out of a total of 592 initial patients enrolled, a total of 360 patients were evaluated in the final statistical analysis, 116 patients presenting with STEMI and 244 presenting with NSTEMI. All patients underwent intensive care admission with mean arterial pressure goal of 65 mmHg as a minimum, heart rate between 40 and 90 beats per minute and goal urine output of 1.5 mL/kg/hour. A total of 82 patients underwent emergent CAG versus 162 undergoing non-emergent CAG within 30 days or less but greater than 12 hours from presentation. Of these patients undergoing emergency CAG, 43 patients had significant lesions over 50% of luminal stenosis with 15 patients undergoing successful PCI at the discretion of the interventional cardiologist. Mean 30-day survival for the NSTEMI group in these patients was reported to be 66% for all patients with emergency CAG regardless of successful intervention or not, compared to 54% in non-emergent CAG patients with NSTEMI and 65% of patients with STEMI undergoing emergent early angiography as per current guidelines. Long-term survival was reported to be 63% in the

STEMI group and 65% and 43% in the NSTEMI groups based upon early versus late angiography strategies. Survival at discharge was associated with good cerebral outcomes as per CPC scoring in the STEMI group (96%) versus the NSTEMI group (94%) though regression analysis showed that NSTEMI with early CAG was not associated with improved CPC scores. While overall survival rates for NSTEMI as reported by Bro-Jeppesen *et al.* was 58%, no benefit was seen in early emergent CAG subgroup analysis through multivariate regression statistics [6]. Due to the lack of statistically significant data for early invasive strategy in NSTEMI patients, the authors recommended further analysis and prospective randomized control trials with larger sample sizes [6]. This is suggested to account for the inherent risks of CAG such as renal disease and bleeding complications in a group of patients in which there is no sufficient evidence yet to fully recommend early invasive strategy as there exists for patients presenting with STEMI.

5. ADDITIONAL DATA AND TRIALS REGARDING POST-ARREST ANGIOGRAPHY WITH ECG FINDINGS OF NSTEMI

Many additional publications have been written regarding the role of cardiac catheterization laboratory in patients with out of hospital cardiac arrest and ECG findings of NSTEMI. While current guidelines remain unclear at the role of angiography in these patients, leaving the decision upon those who provide post-arrest care such as medical intensivists and interventional cardiologists, data does seem to support a role of angiography in identifying culprit lesions and guiding therapy, either medical or interventional. Kern *et al*. in JACC: Cardiovascular Interventions 2015 analyzed 746 comatose post-cardiac arrest patients including 548 without STEMI *via* the International Cardiac Arrest Registry (INTCAR) [7]. While survival for STEMI was greater as compared with NSTEMI, 55.1% versus 41.3%, in subgroup analysis those treated with immediate early CAG showed similar rates of survival on hospital discharge 54.7% versus 57.9%. Patients without STEMI had culprit lesions in 33.2% of patients, with occlusions of these vessels in 69.2% of cases. An occluded culprit lesion in patients with NSTEMI as per the INTCAR registry data shows how coronary reperfusion and CAG can help improve clinical outcomes while also helping to direct medical therapy, just as in patients presenting with STEMI [7].

Millin *et al*. conducted a systemic review through March 1st 2015 of available literature to evaluate whether post-arrest patients with NSTEMI would benefit from percutaneous intervention [4]. 11 articles out of a total of 1067 from the initial screen were included in the final analysis. Results showed that while in cardiac catheterization laboratory 32.2% of patients presenting with arrest and ECG evidence of NSTEMI had angiographic findings of acute culprit lesion as compared to 71.9% of those presenting with STEMI. A limitation of this analysis was the ability to differentiate what patients presenting with NSTEMI would ultimately benefit from early CAG. Regardless, one third of patients were shown to have culprit lesions that could be intervened upon providing some potential benefit from a diagnostic and ultimately survival standpoint influencing outcomes of survival and neurological outcome [4].

While the majority of studies analyzed shockable rhythms of ventricular fibrillation and ventricular tachycardia, Wilson *et al*. analyzed 1396 patients with known initial rhythms to assess whether a difference occurred in coronary interventions through early invasive CAG in patients with non-shockable rhythms [8]. 440 patients with asystole or pulseless electrical activity were further analyzed, with 141 receiving early CAG. A total of 24 patients presenting with NSTEMI received intervention, or 24.7% compared to 54.4% of those with STEMI. The effect of these lesions on arrest was unclear as most patients presenting with out of hospital cardiac arrest present with either acute ischemia leading to STEMI or shockable rhythm [8].

A study of 30 patients undergoing early cardiac catheterization with 17 undergoing early CAG for in-house cardiac arrest with ECG evidence of NSTEMI or no new left bundle branch block was conducted by Merchant *et al*[9]. 10/17 patients had occlusion of over 80% with normal coronaries in 5 patients. PCI was attempted and successfully completed in 29% of patients. 76% survived to hospital discharge but was not found to be statistically significant per regression analysis [9].

The Parisian Region Out of Hospital Cardiac Arrest Registry (PROCAT) was analyzed from January 2003 to December 2008 by Dumas *et al*. [10]. 714 patients were referred with 435 patients with no other non-cardiac cause of arrest included in analysis. An immediate coronary angiogram was performed upon presentation. Significant lesions were noted in a total of 70% percent of patients, 96% of those with ST elevation on ECG (128/134) and 58% of patients without ST elevation on ECG (176/301). Successful angioplasty and intervention was performed in 177 patients total, 99 with ST elevation and 78 without ST elevation. Further analysis showed that angiography that was successful independently predicted survival in patients with cardiac arrest and no other non-cardiac cause, regardless of findings on ECG [10].

6. FURTHER INVESTIGATIONS

While many studies have been shown to help improve survival and neurological function through targeting of culprit lesions in patients presenting with out of hospital cardiac arrest and NSTEMI, current guidelines recommend that providers make the decision to take patients to cardiac catheterization laboratory or not through risk stratification methods, comorbid conditions or presenting symptoms. Guidelines for STEMI and cardiac arrest remain clear, early angiography remains a Class I indication in both ERC and AHA guidelines [1, 2]. The role for early utilization of the cardiac catheterization laboratory to identify lesions and evaluation coronary anatomy requires further study. As such, the Early Coronary Angiography Versus Delayed Coronary Angiography or PEARL study hopes to elucidate further questions surrounding early coronary angiography in patients without ST elevation on presenting ECG [11]. This multi-center study aims to evaluate safety and efficacy of early invasive strategy within 120 minutes of presentation from out of hospital cardiac arrest as the primary endpoint, with survival from hospital at 30 and 180 days post discharge, left ventricular systolic ejection fraction and global ventricular func-

tion *via* echocardiography, CPC and Modified Rankin Score (mRS) as measures of neurocognitive function 180 days post discharge [11]. Studies such as PEARL in addition to the studies discussed previously can help shed light of the positive role cardiac catheterization laboratories can have in helping to improve survival, outcomes and neurological status in patients presenting with NSTEMI following out of hospital cardiac arrest.

CONCLUSION

AHA and ERC guidelines remain clear regarding the positive impact of early angiography and reperfusion improves left ventricular function and survival in patients with out of hospital cardiac arrest and ST elevation on ECG [1, 2]. The role of the coronary catheterization laboratory in patients without ST elevation on presentation is dependent on the physician's assessment of patient's presentation, risk factors and likelihood of coronary artery involvement in patient presentation. An analysis of 5 studies from the 1990s to 2010s [5, 12-15] showed a third of this patient population (972 out of 3121) with OHCA and no ST elevation on ECG had acutely occluded coronary vessels upon angiography. The role of the coronary catheterization laboratory in revascularization of these culprit lesions helps to salvage myocardium and preserve left ventricular systolic function, further preventing recurrent arrest and improving long-term survival after appropriate hypothermia protocol is initiated in order to improve neurological function [1, 2]. Further investigations such as the PEARL study [11] will help to define early invasive strategies as a safe and important measure to help improve survival. Cardiac arrest can be attributed to a variety of causes beyond cardiac such as respiratory, metabolic, infectious or unknown. Evaluation of the coronary arteries to reverse cardiac ischemia in patients with no finding of ST elevation on ECG can help improve survival in patients suffering out of hospital cardiac arrest.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

REFERENCES

[1] O'Conner RE, Ali AA, Brady WJ, *et al*. Part 9: Acute Coronary Syndromes. 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation 2015; 132(18): S483-500.

[2] Nikolaou NI, Arntz HR, Bellou A, *et al*. European Resuscitation Council Guidelines for Resuscitation 2015 Section 8. Initial management of acute coronary syndromes. Resuscitation 2015; 95: 264-77.

[3] Fischer MB, Messerli A, Whayne TF. Characteristics, Management and Results of Out-of-Hospital Cardiac Arrest (OHCA) with or without ST-Segment Elevation Myocardial Infarction (STEMI). Angiology 2017; 1-3.

[4] Millin MG, Comer AC, Nable JV, *et al*. Patients without ST elevation after return of spontaneous circulation may benefit from emergent percutaneous intervention: A systematic review and meta-analysis. Resuscitation 2016; 108: 54-60.

[5] Hollenbeck RD, McPherson JA, Mooney MR, *et al*. Early cardiac catheterization is associated with improved survival in comatose survivors of cardiac arrest without STEMI. Resuscitation 2014; 85: 88-95.

[6] Bro-Jepssen J, Kjaergaard J, Wanscher M, *et al*. Emergency coronary angiography in comatose cardiac arrest patients: Do real-life experiences support the guidelines?. Eur Heart J 2012; 1(4); 291-301.

[7] Kern KB, Lotun K, Patel N, *et al*. Outcomes of comatose cardiac arrest survivors with and without ST-segment elevation myocardial infarction. JACC 2015; 8(8): 1031-40.

[8] Wilson M, Grossestreuer AV, Gaieski DF, *et al*. Incidence of coronary intervention in cardiac arrest survivors of non-shockable initial rhythms and no evidence of ST-elevation MI (STEMI). Resuscitation 2017; 113: 83-6.

[9] Merchant RM, Abella BS, Khan M, *et al*. Cardiac catheterization is underutilized after in-hospital cardiac arrest. Resuscitation 2008; 79: 398-403.

[10] Dumas F, Cariou A, Manzo-Silberman S, *et al*. Immediate percutaneous coronary intervention is associated with better survival after out-of-hospital cardiac arrest: Insights from the PROCAT (Parisian Region Out of Hospital Cardiac Arrest) registry. Circ Cardiovasc Intervent 2010; 3: 200-7.

[11] ClinicalTrails.gov. 2015 March 13. Identifier NCT02387398, Early Coronary Angiography Versus Delayed Coronary Angiography (PEARL). https://clinicaltrials.gov/ct2/show/NCT02387398

[12] Spaulding, CM, Joly LM, Rosenberg A, *et al*. Immediate coronary angiography in survivors of out of hospital cardiac arrest. N Eng J Med 1997. 336; 1629-33.

[13] Radsel, P, Knafelj R, Kocjancic S, *et al*. Angiographic characteristics of coronary disease and postresuscitation electrocardiograms in patients with aborted cardiac arrest outside a hospital. Am J Cardiol 2011; 108(5): 634-8.

[14] Anyfantakis, ZA, Baron, G, Aubry, P, *et al*. Acute coronary angiographic findings in survivors of out-of-hospital cardiac arrest. Am Heart J 2009; 157: 312-8.

[15] Gupta, N, Kontos MC, Gupta A, *et al*. Characteristics and outcomes in patients undergoing percutaneous coronary intervention following cardiac arrest (from the NCDR). Am J Cardiol 2014; 113(7): 1087-92.