Surgical revascularization and perioperative management in patients with non-ST-elevation acute coronary syndromes

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Abstract

Purpose: **The management and surgical revascularization treatment of patients with acute coronary syndromes (ACS) have undergone great evolution over the past decade. The objective of the present study was therefore to analyze the outcome and predictors of survival in patients unresponsive to maximal non-surgical treatment referred to emergency coronary artery bypass grafting (CABG) with ACS.**

Material and methods: **Between October 1999 and September 2004, a total of 3571 CABG patients underwent primary isolated CABG at our institution. Out of these, non-ACS (N-ACS) was present in 3124 patients (group 1), 386 patients (group 2) had non-ST-elevation ACS (NSTE-ACS), whereas 61 patients (group 3) had ST-elevation ACS (STE-ACS). Clinical data, in-hospital morbidity and mortality were prospectively recorded and studied retrospectively in the groups.**

Results: **Left main stem stenosis was observed in 25%, 32%, and 41%, respectively (P<0.02). Previous myocardial infarction was found in 33%, 43%, and 73% (P<0.001). Overall in-hospital mortality was 1.5% in group 1, 4.2% in group 2, and 13.0% in group 3 (P<0.001). Logistic regression and receiver operating characteristic analyses identified cTnI as the strongest preoperative predictor significantly related to in-hospital mortality. A preoperative cTnI level above 1.5 ng/ml was the best single predictor for in-hospital mortality amongst patients with ACS.**

Conclusions: **The present study clearly demonstrates a significant difference of in-hospital morbidity and mortality between patients with ACS undergoing CABG. A more precise patient's risk stratification on admission and improvements in the perioperative management with adjunctive pharmacological therapies and the use of intraaortic balloon counter pulsation may improve patients' outcome.**

Key words: coronary artery bypass grafting, acute coronary syndromes, perioperative management, outcomes.

Introduction

To date, patients undergoing coronary artery bypass grafting (CABG) with acute coronary syndromes (ACS) ranging from unstable angina or acute myocardial infarction (AMI) without ST-segment elevations up to evolving AMI with persistent ST--segment elevations, offer a challenge from the standpoint of diagnosis, treatment, and prognosis, as the clinical manifestations vary considerably. The differences between the entities of ACS are related to the symptoms severity, the initial electrocardiographic pattern, and the degree of acute myocardial cellular necrosis, as expressed by cardiac troponins elevation as a biochemical marker of irreversible myocardial necrosis [1-3]. Patients with ST-elevation acute myocardial infarction have been clearly identified to have an increased risk of suffering death in hospital and, moreover, to have an increased adverse prognosis in the setting of percutaneous coronary intervention [4,5] as well as in patients undergoing emergency CABG [6,7]. However, the reasons for higher adverse prognosis and increased mortality rates in patients with non-ST-elevation ACS (NSTE-ACS) associated with 'minor myocardial damage' resulting in minor elevations of cardiac troponins are not fully understood. Nonetheless, the surgical revascularization in

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patients with ACS has, so far, an important indication based on the obstructive coronary artery lesion; all of them considered of high risk according to the ACC/AHA guidelines [8-10].

The outcomes of patients with ACS undergoing CABG surgery during their hospitalization are expected to be worse than of non-ACS (N-ACS) patients [11,12]. Although there is a plethora of data regarding the outcomes of CABG in general, there are less of contemporary data regarding the frequency and outcomes of CABG among a wide spectrum of patients refferd to CABG due to ACS, although surgical revascularization treatment and management of ACS patients have undergone a great evolution over the past decade [9,12].

The objective of the present study was therefore to analyze the outcome and predictors of survival in patients unresponsive to maximal non-surgical treatment referred to emergency CABG due to ACS at our institution.

Material and methods

Patient population and data collection

From 1999 to 2004, a total of 3510 consecutive patients who underwent primary isolated CABG at the West-German Heart Center Essen were prospectively studied. Of these, 3124 patients had N-ACS (Group 1), whereas a NSTE-ACS (Group 2) was preoperatively identified in 386 CABG patients. NSTE-ACS was supposed to be present if patients had symptoms indicative of an ACS within the preceding 24 hours like new onset of chest pain or accelerating chest pain within the previous 24 hours occurring at rest or with minimal exertion, alleviated by nitroglycerin and/or rest in the absence of ST-segment elevation of >1 mm on the electrocardiogram or with an elevated serum level of cardiac troponin I (cTnI) or creatine kinase (CK) on admission. Informed consent was obtained for all patients and the study protocols were approved by the Institutional Review Board of the West-German Heart Center Essen. Patients were excluded from the study, if any of the following criteria were present: (1) preoperative myocardial infarction with ST-segment elevation on the electrocardiogram (STEMI); (2) new onset left bundle branch block; (3) reoperations; (4) any concomitant heart surgery besides CABG. All clinical data were prospectively recorded and documented with more than 1800 variables per case using a database tool according to the "Heidelberger Verein zur Multizentrischen Datenanalyse e.V." (HVMD) [13].

The primary study endpoint for comparison between the two groups were in-hospital mortality, defined as all cause of death within 30 days after surgery or during the same time period of hospitalization. Secondary study endpoints were postoperative major adverse events (MAE) during the period of hospitalization including: (1) perioperative myocardial infarction (PMI); (2) low cardiac output syndrome (LOS) with high-dose inotropic support with or without requiring the use of an intraaortic balloon counterpulsation; (3) stroke, and minor adverse events like; (4) new-onset ventricular arrhythmias; (5) major bleeding; (6) necessity for rethoracotomy and (7) postoperative renal failure requiring temporary hemodialysis. Perioperative myocardial infarction was considered to have occurred, if one of the following diagnostic criteria were present: (1) a postoperaive cTnI serum level above 10.5 ng/ml within the first 24 hours after CABG, as previously described [14]; (2) the appearance of ST-segment deviations at the J point in two or more contiguous leads with cut-off points ≥0.2 mV in leads V1, V2, or V3 and ≥0.1 mV in other leads or T-wave abnormalities in two or more contiguous leads or the development of new Q-waves [2]. LOS was present, if high-dose inotropic support was necessary in the postoperative course during hospital stay with or without the need of an intraaortic balloon couterpulsation (IABP).

Preoperative risk stratification

In patients with an established diagnosis of ACS, the management strategy to be selected in a particular patient depends on the perceived risk of progression to myocardial infarction or death. All patients presenting with NSTE-ACS were stratified to their individual risk, using the established independent predictors like: (A) markers of thrombotic risk, such as recurrence of chest pain, ECG-changes, or elevated levels of cardiac markers for myocardial damage and severity of coronary artery disease, and (B) risk-factors and comorbidities, such as age, history of previous MI, left ventricular function, renal dysfunction, etc [15-17].

Preoperative management

Patients presenting NSTE-ACS were treated preoperatively on the evidence of clinical trials or meta-analyses with: (1) hemodynamic monitoring; (2) adjunctive pharmacological therapeutic measures, using beta-blockers, nitrates, low-molecular-weight or intravenous heparin, and finally ADP receptor antagonists, such as ticlopidine and clopidogrel resulting in inhibition of platelet aggregation in patients with NSTE-ACS; (3) the optimal timing of CABG surgery, which depends on the preoperative dynamics of acute myocardial injury and (4) the evaluation of the prophylactic use of preoperative IABP treatment, especially in high-risk patients due to (a) impaired left ventricular ejection fraction, (b) preoperative hemodynamic instability with necessity of inotropic support, (c) unstable angina at the time of operation despite intravenous nitroglycerin and heparin, and (d) filiform left mainstem disease or left main equivalent or severe three-vessel disease.

Surgical management

Standard anesthetic and monitoring techniques were used in all patients. Internal thoracic artery, radial artery, and saphenous vein grafts were used as graft conduits. Heparin was administered in order to achieve an activated coagulation time above 400 s. Standard cardiopulmonary bypass (CPB) technique was used with ascending aortic and two-stage venous cannulation. During CPB, moderate hemodilution with a hematocrit level between 20% and 25% using mild systemic hypothermia (>32°C) was maintained. A maximum of myocardial protection was achieved using simultaneous antegrade and retrograde cristalloid cardioplegic arrest (Bretschneider) with additional topical cooling, and single aortic cross clamping for all distal anastomosis. In addition, cardioplegia was administered through the distal grafts until aortic unclamping if necessary. Depending on the severity of coronary artery disease and the

resultant estimated extent of acute myocardial injury, the C-1-esterase inhibitor (Berinert) was administered intravenously 5 minutes before reperfusion. Reperfusion was performed using a modified protocol with aortic systolic blood pressure <50 mmHg at aortic unclamping for the first 3 minutes of reperfusion. Proximal graft anastomoses to the aorta were performed with partial occlusion of the ascending aorta. IABP support was applied intra- and postoperatively according to the morphology of coronary arteries, necessity of inotropic support and/or hemodynamic difficulties during CPB weaning time or in the early postoperative course.

Postoperative management

Postoperative management for high-risk CABG patients was standardized. Patients were monitored with respect to arterial pressure, pulmonary pressure, central venous pressure. A 12-lead ECG as well as the serum biomarkers for myocardial damage, such as cardiac troponin I, myoglobin, and creatin kinase were determined immediately after arrival on the intensive care unit and at 6, 12 and 24 hours postoperatively and once a day thereafter. A medication of 500 mg acetylsalicylic acid was administered intravenously within the first 6 hours after surgery in the absence of significant bleeding.

Statistical analysis

Data are reported as mean ±SD and categorical variables by their percentage. For all categorical variables the odds ratios (OR) and 95% confidence intervals (CI) were calculated. Comparisons of categorical variables between the groups were performed by Pearson's Chi-square test, since expected frequencies <5 occurred all P values were calculated exactly. Comparisons of continuous variables between groups were analyzed by students t-test. Univariate and multivariate logistic regression analyses were performed to identify preoperative independent predictors for in-hospital mortality. All preoperative predictor variables that were identified as significant at a two-tailed nominal P value of less than 0.10 in univariate regression analysis were then entered into a multivariate logistic regression analysis model. Receiver operating curve (ROC) analyses were applied to determine optimal cut-off values of cTnI and to evaluate the predictive power for in-hospital mortality. A P value less than 0.05 was considered to indicate statistical significance. All statistical analyses between groups were performed using the SPSS software package (SPSS Inc., Chicago, IL, USA).

Results

The demographics and baseline data of the two groups are summarized in *Tab. 1*. Preoperative baseline characteristics and demographics of the patients were comparable with the contemporary coronary surgery patient profile. A preoperative significant difference between the groups could be observed in terms of age, smoking history, previous myocardial infarction, symptoms of angina, left mainstem disease, left ventricular ejection fraction as well as the preoperative cTnI serum level (*Fig. 2A*) and CK activity. The preoperative cTnI serum level was likewise significantly different according to the survival staus of the entire study cohort (*Fig. 2B*). As demonstrated in *Tab. 2* the intraoperative data did not differ between the groups, except the amount of cardioplegia to be used, which was slightly but significantly more in group 2 compared to group 1 (P=0.01). The aortic cross clamping time and the cardiopulmonary bypass time tended to be longer in group 2. The number of graft conduits per patient did not differ between the groups and the percentage of internal mammary artery grafts to be used was also not different. The intraoperative mean graft flow, as measured by Doppler flowmetry, did also not differ between the groups. According to the postoperative data, as shown in *Tab. 2* and *Fig. 1*, a significant difference in the necessity for intraoperative and postoperative intraaortic balloon pump (IABP) support between the groups (P<0.001) accompanied by a significantly prolonged postoperative ventilation time (P<0.001) and a longer ICU stay (P<0.001) could be observed. Among the 3124 patients with N-ACS of group 1, 47 (1.5%) died

Table 1. **Baseline characteristics**

	Group 1 N-ACS (n=3124)	Group 2 NSTE-ACS (n=386)	P value
Demographics			
Age, y	66±9	67±9	0.01
Gender, female	635 (20)	95 (25)	0.11
Body weight, kg	81±14	82±16	0.44
Cardiovascular risk factors			
Diabetes mellitus	941 (30)	122 (30)	0.72
Hypertension	2588 (83)	333 (86)	0.15
Hyperlipidemia	2525 (81)	295 (76)	0.09
Family history	1409 (45)	178 (45)	0.82
Smoking history	1902 (61)	199 (62)	0.004
Comorbidities			
History of stroke	221 (7)	22 (6)	0.77
COPD	497 (16)	70 (16)	0.18
PVD	472 (15)	54 (15)	0.62
Renal disease*	436 (14)	51 (13)	0.92
Dialysis	65 (2)	7 (2)	0.59
Cardiac history			
Previous MI**	1028 (33)	189 (43)	<0.0001
Previous PCI	625 (20)	66 (17)	0.18
CCS III-IV	1839 (59)	268 (66)	0.0001
Extent of CAD			
Left-mainstem disease	782 (25)	123 (32)	0.02
One-vessel disease	90 (3)	11 (4)	0.06
Two-vessel disease	472 (15)	57 (14)	0.44
Three-vessel disease	2595 (83)	318 (82)	0.97
LV function			
LV-EF, %	60±15	56±15	<0.0001
Preoperative serum marker			
cTnI, ng/mL	0.03±0.04	2.4±7.6	<0.0001
CK, IU/L	55±63	85±120	<0.0001

Data are presented as mean ±SD or number (%); COPD – Chronic obstructive pulmonary disease; PVD – Peripheral vascular disease; MI – Myocardial infarction; PCI – Percutaneous coronary intervention; CCS – Canadian Cardiovascular Society; CAD – Coronary artery disease; LV – Left ventricle; EF – Ejection fraction; * – Serum Creatinine >0.2 μmol/l; ** – >7 days

Figure 1. **Preoperative, intraoperative and postoperative use of intraaortic ballon counterpulsation support in CABG patients with NACS versus NSTE-ACS (P<0.001)**

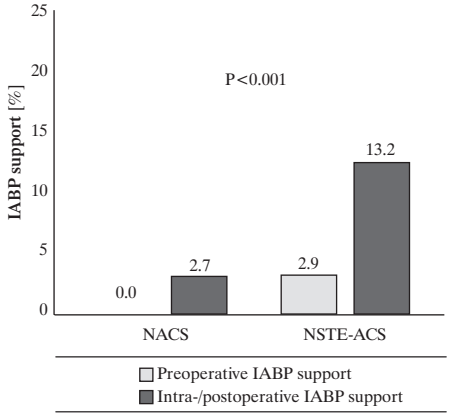
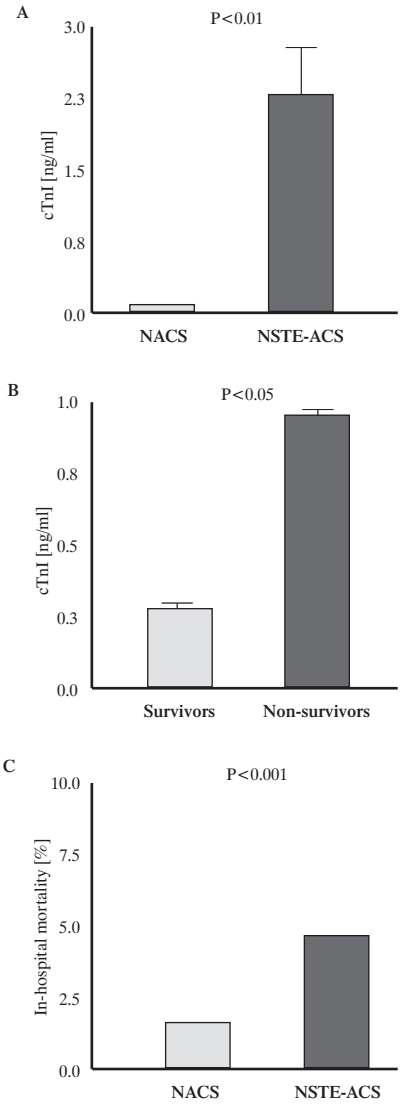


Table 2. **Intra- and postoperative characteristics**

	Group 1 N-ACS (n=3124)	Group 2 NSTE-ACS (n=386)	OR (95% CI)	P value
Intraoperative data				
ACC time, min	68±23	72±23	–	0.19
CPB time, min	106±39	110±33	–	0.21
Cardioplegia, mL	1516±473	1579±445	–	0.01
Reperfusion time, min	31±16	34±14	–	0.11
Grafts per patient, n	3.0±0.8	3.0±0.8	–	0.30
Postoperative data				
Ventilation time, h	8 (7-11)	8 (7-13)	–	<0.001
IABP support	84 (2.7)	51 (13)	5.5(3.8-8.1)	<0.001
ICU stay, d	1 (1-2)	1 (1-4)	–	<0.001
Hospital stay, d	8 (6-12)	8 (6-12)	–	0.21
Major adverse events				
Death in hospital	47 (1.5)	16 (4.2)	2.8(1.5-5.2)	<0.001
LCOS	48 (1.5)	22 (5.7)	3.9(2.2-6.7)	<0.001
PMI	171 (5.5)	44 (11.5)	2.2(1.5-3.2)	<0.001
Stroke	62 (2.0)	6 (1.6)	0.8(0.3-1.9)	0.56
Other complications				
Major bleeding	110 (3.5)	11 (2.8)	0.8(0.4-1.6)	0.50
Rethoracotomy	88 (2.8)	16 (4.1)	1.5(0.8-2.6)	0.15
Arrhythmia	410 (13)	78 (20)	1.7(1.3-2.1)	<0.001
Renal failure (dialysis)	172 (5.5)	62 (16)	3.3(2.4-4.5)	<0.001

Data are presented as mean ±SD, median (25% – 75% Interquartile) or number (%); ACC – Aortic cross-clamp; CPB – Cardiopulmonary bypass; IABP – Intraaortic ballon counterpulsation; ICU – Intensive care unit; LOS – Low cardiac output syndrome; PMI – Perioperative myocardial infarction; OR – odds ratio and 95% confidence interval between group 1 and 2

Figure 2. **(A) Preoperative serum cTnI levels in patients with NACS versus NSTE-ACS (P<0.01). (B) Prognostic value of pre-CABG cTnI serum levels: survival status of the entire study cohort according to pre-CABG cTnI levels (P<0.05). (C) In-hospital mortality in CABG patients with NACS versus NSTE-ACS (P<0.001)**



in the postoperative course within 30 days or within the same time of hospital stay, whereas 16 (4.2%) deaths occurred among 386 patients with NSTE-ACS in group 2 (P<0.001; *Fig. 2C*). The difference of in-hospital mortality was accompanied by a significant difference in the appearence of postoperative low cardiac output syndrome (P<0.001) and the incidence of perioperative myocardial infarction (P<0.001). The incidence of postoperative stroke was not significantly different. Other postoperative complications and adverse events like major bleeding (>200 ml/h first 6 h) and all causes of rethoracotomy were not different between the groups. The occurrence of new-onset arrhythmia (P<0.001) and the incidence of postoperative renal failure requiring temporary veno-venous hemofiltration or hemodialysis was significantly different between the two groups (P<0.001).

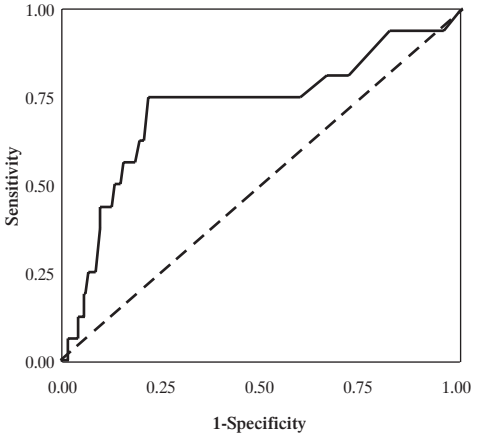
Univariate and multivariate logistic regression analyses identified a number of risk factors and preoperative variables like age, peripheral vascular disease, previous PCI, angina class and preoperative cTnI serum level to be related with in-hospital mortality. These independent predictors of death are detailed in *Tab. 4*. In this regard, the preoperative cTnI serum level

***Table 4*. Univariate and multivariate logistic regression analysis of variables between groups 1 and 2**

	Univariate Regression Analysis		Multivariate Regeression Analysis	
	Odds Ratio [95% CI]	P Value	Odds Ratio [95% CI]	P Value
Age	1.1 (1.0-1.1)	<0.001	1.1 (1.0-1.1)	0.02
Gender	2.1 (1.1-4.1)	0.02	1.3 (0.6-2.8)	0.46
Obesity	0.9 (0.5-1.7)	0.80	—	—
Smoking	0.4 (0.2-0.8)	0.01	0.6 (0.3-1.2)	0.17
Diabetes mellitus	1.9 (1.0-3.5)	0.05	1.3 (0.7-2.7)	0.44
Hypertension	3.8 (0.9-15.9)	0.07	2.1 (0.5-8.9)	0.33
Hyperlipidemia	1.8 (0.7-4.5)	0.24	—	—
Renal disease	1.0 (0.3-2.8)	0.96	—	—
COPD	1.5 (0.7-3.2)	0.29	—	—
PVD	2.6 (1.3-5.2)	0.01	2.5 (1.2-5.2)	0.01
Previous MI	1.5 (0.8-2.9)	0.19	—	—
Previous PCI	2.4 (1.2-4.7)	0.01	2.7 (1.3-5.6)	0.01
Angina Class III-IV	5.5 (2.0-15.5)	0.01	3.5 (1.2-10.2)	0.02
Left-mainstem disease	1.0 (0.5-2.0)	0.91	—	—
LV-EF (%)	0.98 (0.96-1.0)	0.12	—	—
CK (IU/L)	1.0 (0.99-1.0)	0.62	—	—
cTnI (ng/mL)	1.1 (1.0-1.1)	<0.0001	1.1 (1.0-1.1)	<0.001

* – All cause of death; CI – Confidence interval

***Figure 3*. ROC curve analysis demonstrating the discriminatory power of preoperative cTnI levels for in-hospital mortality. The optimal per-CABG cTnI serum level was found with 1.5 ng/ml with an area under curve of 0.72±0.08, a sensitivitiy of 75.0% and a specificity of 78.5%**



was found to be the strongest independent risk factor for death (P<0.0001). The discriminative power of the preoperative cTnI serum level for in-hospital mortality by using a receiver operating characteristic (ROC) curve analysis revealed an optimal cTnI cut-off value of 1.5 ng/ml, with an area under curve of 0.72±0.08, a sensitivitiy of 75.0% and a specificity of 78.5% (*Fig. 3*).

Discussion

Our findings in the present study suggest that in a surgical population of patients undergoing CABG, the existence of preoperative non-ST-elevation ACS is associated with a significantly higher mortality within 30 days and a higher incidence of major adverse cardiac events, such as perioperative myocardial infarction or low cardiac output syndrome. Moreover, the present study could clearly demonstrate, that increased mortality rates after CABG due to NSTE-ACS are significantly associated with several independent preoperative predictors, most notably, with the degree of preoperative cTnI serum elevation. Furthermore, the present study suggest that the surgical revascularization with the concomitant perioperative management strategies is safe and effective in the clinical course of patients presenting NSTE-ACS. At our institution, the average mortality rate was 4.2% during hospital stay or within 30 days for CABG patients with NSTE-ASC, which was significantly higher compared to CABG patients without ACS during the same interval. This overall hospital mortality rate is well in the range of actual data of the current literature [11].

Multiple studies have shown that patients undergoing coronary artery bypass grafting who present acute myocardial infarction with ST-segment elevations on the electrocardiogram have an clearly increased risk of suffering death in hospital. It has been clearly shown that emergency revasculratzation of patients with an acute transmural myocardial infarction have an increased adverse prognosis in the setting of percutaneous coronary intervention [5,18] as well as in patients following emergency CABG [6,7]. However, the occurences and reasons for higher adverse prognosis and increased mortality rates in patients with non-ST-elevation ACS (NSTE-ACS) associated with 'minor myocardial damage' resulting in minor elevations of cardiac troponins are not fully understood. In the setting of ACS, elevations of cardiac troponins were found to be associated with multivessel disease, complex coronary lesions with unstable and ruptured plaques, distal coronary microembolization of platelet microaggregates and plaque debris [19,20] as

well as abnormal microvascular myocardial perfusion [5], which might be an alternative or contributory cause of elevations of cardiac troponins. In several recent studies, it has been shown that patients with unstable CAD and elevated cardiac troponins had more widespread CAD than those without elevated cardiac troponins and had more often complex coronary lesions and visible thrombus in the culprit vessel [21,22]. It has also been demonstrated, that minor elevations of cardiac troponins and thus, a 'minor myocardial damage', is present in approximately 30% of patients with rest angina and negative CK/CK-MB values [23].

According to risk stratification among patients with NSTE-ACS, there is an increased risk of death within 6 weeks in those with elevated serum levels of cardiac troponins and the risk of death continues to increase as the cardiac troponin serum level increases [8,10]. Reversible ST-segment depression is associated with an increase by a factor of 3-6 in the likelihood of death, myocardial infarction, ischemia at rest, or provocable ischemia during a test to stratify risk. Although the conditions of the majority of patients with unstable angina will stabilize with effective antiischemic medications, approximately 50-60% of such patients will require revascularization treatment because of the "unresponsiveness" of medical therapy [12]. High-risk patients are those who have had angina at rest, prolonged angina, or persistent angina with positive serum levels of cardiac troponins or dynamic ST-segment changes or hemodynamic instability, and these patients urgently require invasive diagnostic evaluation and subsequent revascularization treatment. In accordance to the present guidelines of the ACC/AHA, patients with NSTE-ACS require, first of all, an aggressive medical treatment in order to stabilize and control the symptoms if possible. Medical therapy should be adjusted rapidly to relieve manifestations of ischemia and should include antiplatelet therapy (aspirin, or ticlopidine or clopidogrel if aspirin is contraindicated), antithrombotic therapy (unfractionated heparin or low-molecular-weight heparin), beta-blockers, nitrates, and possibly calcium-channel blockers. Early administration of glycoprotein IIb/IIIa inhibitors may be particularly important, especially in high-risk patients with positive troponin tests or those in whom implantation of coronary stents is anticipated [8-10]. However, even in patients with NSTE-ACS were surgical revascularization is indicated, a recently published randomized trial have demonstrated that the benefit (freedom from cardiovascular death, MI, stroke) of administering clopidogrel early on admission appear to outweight the risk of life-threatening bleeding in patients with NSTE-ACS following CABG [24].

Surgical myocardial revascularization with CABG for patients with unstable angina and left main stem stenosis or equivalent with evidence of myocardial ischemia, or with triple vessel disease and impaired left ventricular function, improves prognosis and has, so far, a clear indication based on the obstructive coronary artery lesion; all of them considered of high-risk according to the ACC/AHA guidelines [8-10]. The perioperative treatment strategies of NSTE-ACS patients undergoing CABG are basically based on numerous suggestions and recommendations that have been made to reduce the risk for CABG surgery in patients with AMI 'in general', including better selection and optimal timing of surgery [7], adjunctive pharmacological therapy [25], and accurately timed IABP support [26].

The benefical effects of preoperative IABP treatment on outcome in high-risk patients have been clearly demonstrated in several non-randomized and randomized trials. Even in patients undergoing CABG with preoperative evidence of myocardial ischemia and/or preoperative hemodynamic instability, there is strong evidence of the benefical effect for preoperative and intraoperative use of the IABP [26-28].

The optimal timing of surgical revascularization in patients with AMI has been described in several previous studies. It has been shown that hospital mortality decreases with increasing time interval between CABG and AMI [7,29]. However, no data are currently available according to the optimal timing of CABG in patients with NSTE-ACS. At our institution, the timing for surgery of patients with NSTE-ACS was depending on the severity of symptoms and the level and/or kinetic of preoperative cTnI value indicating ongoing myocardial ischemia despite maximal non-surgical therapy on the one hand, and the complexity and severity of the coronary artery lesions on the other hand.

In terms of using the optimal myocardial protection during CABG, the type of cardioplegia (blood versus cristalloid, warm versus cold) has been the subject of numerous experimental and clinical studies, but this issue still remains controversial [30-32]. The benefical effect with optimal delivery of the cardioplegic solution by the use of simultaneous antegrade/retrograde cardioplegia and additional administration through the distal grafts, however, have been clearly demonstrated [33-35].

The adjunctive pharmacological therapy and thus, the optimal cardiac protection during AMI and/or myocardial injury due to ischemia/reperfusion is still a challenging field of cardiovascular research since numerous treatment options have been investigated so far to reduce myocardial infact size. Intravenous beta-blockers administered in the early hours of infarction were clearly shown to be of benefit [36]. Intravenous adenosine appeared promising for AMIs and myocardial protection during CABG, as did C1-esterase inhibitors and cariporide in some studies [37-40]. However, the majority of other medications were studied with negative or marginal results. Moreover, no data are currently available according to the optimal adjunctive pharmacological therapy of patients undergoing CABG with NSTE-ACS.

Conclusions

The present study demonstrates a significantly higher risk for patients with NSTE-ACS undergoing surgical revascularization compared to patients with N-ACS with significantly increased in-hospital morbidity and mortality rates. Multivariate logistic regression analysis revealed the preoperative cardiac troponin I level as the most strongest independent predictor of death in-hospital. Therefore, a more precise patient's risk assessment and a tailored perioperative management strategy may improve patients outcome.

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