Original Article

Results and Treatment Strategy for Patients Undergoing Emergent Coronary Artery Bypass Grafting

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Background: Emergent coronary artery bypass grafting (CABG) remains a high-risk procedure in cardiac surgery. Therefore we performed this study to evaluate its current results.
Methods: From 2001 to 2007, fifty-seven patients with an acute coronary syndrome underwent an isolated CABG procedure emergently. Data were collected retrospectively from the patients' charts.
Results: The mean age of the patients, 45 males (79%) and 12 females (21%), was 64.5 ± 11.5 years. Operations were performed on 40 patients (70%) with cardiopulmonary bypass (CPB) and cardioplegic cardiac arrest and on 6 without CPB. Eleven patients (11%) underwent on-pump beating heart procedures (19%). The operating times (minutes) were duration of surgery 215.2 ± 64.2; duration of CPB 116.9 ± 51.5; and X-clamp time 57.3 ± 19.9. The mean number of grafts per patient was 2.95 ± 0.97. Postoperative durations of mechanical ventilation (hours), Intensive Care Unit stay (days), and normal ward stay (days) were 45.8 ± 75.3, 8.9 ± 23.1, and 9.6 ± 8.0, respectively. The total number of complications was 57, and postoperative confusion (29.8%), revision for bleeding (22.8%), and renal insufficiency (21%) occurred most frequently. Seven of the 57 patients died: 5 succumbed to multiorgan failures, 1 to cardiac decompensation, and 1 to bleeding complications.
Conclusion: Emergent CABG is associated with an enhanced perioperative risk, and further developments are absolutely necessary to improve its results. (Ann Thorac Cardiovasc Surg 2010; 16: 168–173)

Key words: coronary artery bypass grafting, emergent surgery

Introduction

Despite great progress in the conservative and interventional treatment of patients with acute coronary syndromes, in Germany the percentage of patients still dying from this problem ranges from 5% to 10%. Within the next year, 25% of male patients and 38% of female patients will not live through the consequences of this event.[1] Therefore the major goal in these patients remains the revascularization of the ischemic myocardium to lower the mortality and to improve long-term survival.

The last therapeutic option for patients with ongoing angina pectoris, despite maximal conservative and interventional therapy, is operative revascularization. This procedure, which must be performed on an emergent basis, is associated with an increased risk compared with elective operations. Therefore we performed this study to evaluate the perioperative risk of emergent coronary artery bypass grafting (CABG) and to discuss the optimal treatment strategy for this high-risk patient group.

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Table 1. Concomitant diseases

	Number of patients	Percentage
Arterial hypertension	49	86
Previous myocardial infarction	38	67
Hyperlipidemia	37	65
Nicotine abuse	32	56
Diabetes mellitus	11	19
Acute cardiac decompensation	9	16
Peripheral arterial occlusive disease	8	14
Previous cerebral infarction	2	4

Table 1 demonstrates that the most common concomitant disease was arterial hypertension, followed by previous myocardial infarction and hyperlipidemia.

Table 2. Preoperative anticoagulation management

	Number of patients	Percentage
Heparin	42	74
acetylsalicylic acid	42	74
clopidogrel	28	49
glycoprotein IIb/IIIa inhibitors	19	33
phenprocoumon	1	2

Table 2 clearly shows that nearly all patients were treated with a combination of anticoagulative drugs, indicating the severity of the disease in this patient cohort.

Materials and Methods

From 2001 to 2007, a total of 57 patients with acute coronary syndrome were operated emergently in the Department of Cardiothoracic Surgery of the University of Aachen. Emergent surgery means that all these patients underwent CABG within 2 hours after admission to our department because of ongoing angina, despite optimal conservative and interventional treatment. Twenty-eight patients (49%) suffered from an acute ST elevation myocardial infarction, whereas the remaining 29 had acute coronary syndromes with no changes in the electrocardiogram. All patients underwent an isolated CABG procedure; patients with a simultaneous procedure (for example, valve surgery) or who had previously experienced a cardiac operation were excluded from the study. Data were collected retrospectively from the patient's charts and are presented as mean value and standard deviation of the mean.

Results

Preoperative data

The mean age of these patients was 64.5 ± 11.5 years at the time of surgery. The number of male patients was 45 (79%) and of female patients 12 (21%). The mean body mass index was slightly enhanced (27.5 ± 4.2 kg/m^2), whereas the ejection fraction was somewhat decreased (56.9 ± 20.4%). Table 1 presents the concomitant diseases of the patients.

Forty patients (70%) suffered from a 3-vessel disease, 14 (25%) from a 2-vessel disease, and 3 (5%) from a single-vessel disease. All patients were evaluated for percutaneous coronary intervention. This treatment failed in 15 patients (26%, unsuccessful percutaneous transluminal coronary angioplasty or failed stent implantation); thus these patients were referred directly to cardiac surgery from the cardiac catheterization laboratory. The remaining 42 patients suffered from a left main stenosis or an advanced coronary artery disease (serial high-grade stenoses or a diffuse coronary artery disease). Thus the anatomy was evaluated as being unsuitable for an interventional procedure from the cardiologists. Four patients had to be supported by an intra-aortic balloon pump for ongoing angina pectoris, despite maximal conservative therapy. These four received the pump while in the cardiac catheterization laboratory and were therefore referred to the operating room in that condition. Two of these patients were already intubated and treated with catecholamines because of hemodynamic instability. Three other patients could be stabilized by intravenous catecholamine administration.

The preoperative anticoagulation management is shown in Table 2.

Operative data

All patients were operated on via a median sternotomy. Cardiopulmonary bypass with cardioplegic cardiac arrest (Bretschneider's solution) was used in 40 patients (70%). Eleven patients underwent an on-pump beating heart procedure (19%), and 6 had operations without cardiopulmonary bypass (11%). All patients having operations without cardiopulmonary bypass received an intra-aortic balloon pump routinely before skin incision to secure hemodynamic stability during the phases of cardiac displacement. In two patients, weaning from cardiopulmonary bypass was not possible despite catecholamine support and implantation of an intra-aortic pump, making an extracorporeal membrane oxygenation (ECMO) implantation necessary. Table 3 presents the durations of surgery, cardiopulmonary bypass, and aortic cross-clamping. The number of bypass grafts is shown in Table 4.

Intraoperative anticoagulation was performed with

Table 3. Operating times

Duration of surgery (minutes)	215.2 ± 64.2
Duration of cardiopulmonary bypass (minutes)	116.9 ± 51.5
X-clamp time (minutes)	57.3 ± 19.9

It should be considered that the number of patients is 57 for the duration of the operation, 51 for the duration of the cardiopulmonary bypass, and 40 for the X-clamp time.

Table 4. Number of bypass grafts

	Number of patients	Percentage
One graft	1	1.8
Two grafts	19	33.3
Three grafts	23	40.3
Four grafts	11	19.3
Five grafts	2	3.5
Six grafts	1	1.8

All grafts were performed as single grafts. The mean number of grafts per patient was 2.95 ± 0.97. The left internal thoracic artery was used in 44 patients (77%) as a graft to the left anterior descending coronary artery; the other grafts were performed with segments of the greater saphenous vein.

heparin. The activated coagulation time was adjusted to > 400 seconds in patients operated on with cardiopulmonary bypass and to > 300 seconds in those operated on without it. After termination of cardiopulmonary bypass or completion of bypass grafts, the heparin effect was reversed by protamine. In patients who received phenprocoumon preoperatively, the prothrombin time was increased to above 50% by using fresh frozen plasma or PPSB (containing coagulation factors II, VII, IX, and X in very high concentrations) if the effect of fresh frozen plasmas was insufficient. If the drainage loss was less than 100 mL per hour for more than six hours postoperatively, all patients received acetylsalicylic acid. Those with highly progredient coronary artery disease or a coronary stent also received clopidogrel. Patients with a preoperative phenprocoumon therapy were also treated with phenprocoumon postoperatively after removal of the chest tubes.

Postoperative data

The most important postoperative data and complications are given in Tables 5 and 6.

Postoperative cardiac arrhythmias were detected in 26 patients (45.6%). Twelve (21%) suffered from a tachyarrhythmia absoluta (atrial fibrillation > 100 bpm) and 6 from ventricular extrasystoles (11%), which could be treated conservatively. Four patients had a third-degree atrioventricular block (7%) and two had bradycardias (3.5%), which required temporary pacemaker stimulation. Two patients (7%) developed ventricular fibrillation postoperatively, which in one was treated successfully by cardiac defibrillation.

An intraoperative myocardial infarction could not be clearly detected. As shown in Fig. 1, the CK-MB fraction was already increased significantly before surgery (14%, day -1) and declined continuously in the postoperative course. This indicates that the extent of the myocardial damage was more dependent on the preoperative situation than on the operative myocardial injury.

Seven of the 57 patients died postoperatively. Five succumbed to multiorgan failure, 1 could not be resuscitated after a cardiac decompensation resulting in ventricular fibrillation, and 1 died because of hemodynamic instability that occurred during a revision for a retroperitoneal bleeding complication.

Discussion

In 1999, Hochman et al.[2] demonstrated that an early revascularization (CABG or PCI = percutaneous coronary intervention) of patients with an acute myocardial infarction complicated by a cardiogenic shock does not reduce the overall mortality at 30 days, but it significantly improves midterm survival at six months. Six years later, White et al.[3] presented a more detailed analysis of the subgroup of patients who underwent an early revascularization and compared them with CABG and PCI. The authors found no significant difference of survival after 30 days or after 1 year. However, patients undergoing CABG suffered from more-severe coronary artery disease (for example: occlusion of the left main stem 41.3% vs. 13.0%, and 3-vessel-disease 80.4% vs. 60.3%) and more frequently demonstrated diabetes mellitus (48.9% vs. 26.9%). These results may lead to the assumption that long-term results of CABG would be better than after PCI if both patient groups were comparable. This problem was addressed by a study that Toda et al. conducted.[4] They compared the results of CABG and PCI in patients with ischemic heart disease and severe left ventricular dysfunction and concluded that CABG achieved a more complete revascularization and improved left ventricular function, and also that it led to fewer cardiac events and reinterventions after three years.

Taking everything into account, Makuuchi.[5] defined the indications for PCI and CABG as follows: PCI is the

Table 5. Postoperative data

Duration of mechanical ventilation (hours)	45.8 ± 75.3
Stay on the Intensive Care Unit (days)	8.9 ± 23.1
Stay on the normal ward (days)	9.6 ± 8.0
Blood loss (mL)	1232 ± 1015
Transfused Packed red blood cells	5.4 ± 7.3
Transfused Fresh frozen plasma	2.5 ± 5.0
Transfused Platelet concentrates	0.9 ± 2.3

Regarding Table 5, the high standard deviation for all parameters is striking. Especially the times for postoperative ventilation and stay on the intensive care unit are prolonged by some patients who suffered from serious postoperative complications and ultimately died. The values of drainage loss and number of applied blood products are caused by numerous patients who received no transfusions and had a low drainage loss, and by some patients who had a very high drainage loss and received many blood products (especially the patients who had to be revised for a bleeding complication). Altogether, 44 patients (77%) received packed red blood cells, but only 21 (37%) received fresh frozen plasmas, and 18 (32%) received platelet concentrates.

Table 6. Postoperative complications

	Number of patients	Percentage
Postoperative confusion	17	29.8
Revision for bleeding	13	22.8
Renal insufficiency	12	21
Need for IABP insertion intraoperatively	8	14
Need for an ECMO intraoperatively	2	3.5
Superficial wound healing disturbance	2	3.5
Mediastinitis	2	3.5
Cerebral infarction	1	1.8

The postoperative confusion was successfully treated by drugs in all patients. The 13 revisions for bleeding were performed in 10 patients. The reasons were a diffuse bleeding tendency for 9 revisions (mediastinal hematoma: 5 patients; left-sided hemothorax: 2 patients; retroperitoneal bleeding after IABP [intra-aortic balloon pump] insertion: 2 patients) and a pericardial tamponade 4 times. All patients who had to be revised for bleeding complications received more than one anticoagulative drug preoperatively. Five of the 12 patients with postoperative renal insufficiency already had an impaired renal function preoperatively. Eleven had to undergo a temporary dialysis, but renal function recovered to the preoperative status in the surviving patients. The superficial wound-healing disturbances could be treated conservatively, whereas the 2 patients suffering from a mediastinitis had to be treated surgically. ECMO = extracorporeal membrane oxygenation

therapy of choice for acute coronary syndromes, especially when the patient is in cardiogenic shock. In cases of acute myocardial infarction, emergent CABG is indicated when a left main trunk lesion or severe triple-vessel disease remains after PCI combined with residual or recurrent ischemic angina and/or ST changes in the electrocardiogram. Similarly, in cases of unstable angina, emergent CABG is indicated when a left main trunk lesion or a left main trunk equivalent (proximal stenosis of the left anterior descending coronary artery and the circumflex branch) is the culprit lesion or when severe triple-vessel disease exists.

On the other hand, emergent operation and existence of cardiogenic shock are the major perioperative risk factors for CABG in patients with acute coronary syndromes. Because employment of a cardiopulmonary bypass and cardioplegic arrest greatly contribute to surgical mortality, less-invasive operative strategies such as on-pump beating heart and off-pump surgery have become more popular in recent years.[5] Various studies tried to address the question of whether these less-invasive procedures result in an improved outcome of patients with emergent CABG. Rastan et al.[6] demonstrated that patients undergoing on- and off-pump beating heart surgeries had lower drainage losses, a reduced need for transfusions, a shorter duration of postoperative mechanical ventilation and stay in the intensive care unit, and a decreased frequency of cerebral infarctions. This led to better in-hospital results

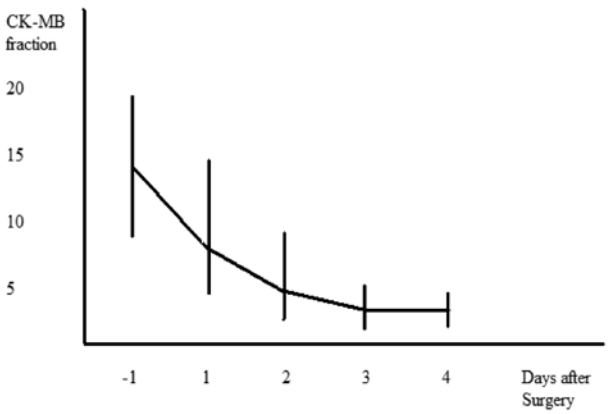

Fig. 1. Perioperative course of the CK-MB fraction (CK-MB divided by CK in percent)

for these patients, which might be explained by less myocardial damage when the use of cardioplegic solution, and possibly also cardiopulmonary bypass, is avoided.[7] But the overall survival and the frequency of cardiac events as well as reinterventions were comparable at five

years. Similar results were reported by other authors.[8,9] But off-pump CABG, which leads to the lowest myocardial damage, is difficult to perform when the hemodynamic state is unstable.[5] Therefore it was thought that the development of miniaturized cardiopulmonary bypass systems[10,11] would solve this problem.

First reports demonstrated that the inflammatory response was reduced with miniaturized cardiopulmonary bypass systems as a result of the decreased hemodilution (leading to lower requirements of blood transfusions) and limited air-blood contact.[12,13] Also, Fromes et al.[14] showed that miniaturized cardiopulmonary bypass systems led to significantly lower Il-6 levels and significantly less increase of the TNF-Alpha. Unfortunately, however, Rex et al.[13] could not confirm these results. They failed to show a decreased release of the proinflammatory IL-6. Furthermore, only the conventional cardiopulmonary bypass system was associated with a significant increase in the release of the anti-inflammatory cytokine IL-10.[13] Therefore the primary enthusiasm regarding miniaturized cardiopulmonary bypass systems has gone, and the question of which operative strategy is the best one for a certain patient remains. Until now, no consensus has remained concerning the precise indications for either off-pump or on-pump beating heart and for on-pump surgery with cardioplegic arrest. Some authors still prefer the conventional technique with cardiopulmonary bypass and cardioplegic arrest for patients with left main stem disease and patients with 3-vessel disease.[3,6] But in general, the choice of surgical technique rests largely with the operating surgeon and his evaluation of the patient's condition.

Lastly, the question of the true perioperative risk of emergent CABG remains. Many reports have addressed this problem, and mortality rates from 2.7% up to 42.6% are described.[3,15] The low mortality rate of the first study may be explained by their being only 37 patients involved, whereas the high mortality rate of the second study probably was caused by the severity of the disease (acute myocardial infarction complicated by cardiogenic shock in all patients). Usually, mortality rates from 10.7% to 20.8% are reported for emergent CABG.[16-18] These rates are significantly increased when compared with elective CABG (1.4%,[17]) but it must be considered that emergent CABG is always the last therapeutic option for severely ill patients. Therefore there is no other way than to accept this risk today, but efforts must proceed to reduce it.

Conclusion

Today, emergent CABG is an operative procedure with a significant increased risk that is markedly influenced by the preoperative status of the patient. Therefore great endeavors must be made to optimize the preoperative patient's condition and to reduce the operative invasiveness to improve the overall outcome of these high-risk patient groups.

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