Original article

Acta Medica Academica 2017;46(1):1-6
DOI: 10.5644/ama2006-124.180

Surgical coronary revascularization on-pump versus off-pump in patients with stenosis of the main tree of the left coronary artery and carotid stenosis

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Received: 29 October 2016
Accepted: 10 May 2017

Key words: Coronary artery bypass grafting ▪ Off-pump ▪ Left main stenosis ▪ Carotid stenosis ▪ Cerebrovascular insult.

Objective. The aim of this study was to show perioperative complications of CABG procedure with and without cardiopulmonary bypass (CPB) in patients with combined coronary and carotid disease. **Patients and methods.** This retrospective survey included patients with left main stenosis greater than 50% and carotid stenosis over 50%, who had undergone CABG without carotid endarterectomy at the BH Heart Centre, from May 2009 to May 2014. The patients were divided into two groups according to the surgical method used. Group A consisted of 50 patients who underwent surgery without CPB and the second group of 50 patients with CPB, conformed according to gender, ejection fraction values, EuroSCORE and the number of bypass grafts performed. **Results.** Analysis of the basic results indicates significant differences between the groups in the time spent on a respirator or time in the ICU, the amount of postoperative bleeding or compensated blood, as well as subsequent complications. The overall incidence of neurological complications showed a difference in the observed groups. **Conclusion.** With ever easier technical performance, complete planned revascularization and the quality of performed grafts, the conditions have been created for a comparative analysis. According to the results we can say that CABG without CPB has a number of advantages over the other method, in patients with the combined disease.

Introduction

Atherosclerosis is a process that simultaneously affects the carotid and coronary arteries. It is estimated that these two conditions can coexist within a range of 2-20%, with an average incidence of 8% (1-8). Numerous statements confirm this fact. Hedelbad and associates (8) proved that more than 50% of patients, suffering from carotid arteries stenosis, simultaneously show symptoms of ischemic or coronary heart disease (9, 10). Also, it was found that in 19% of patients, with the need for coronary revascularization (coronary artery bypass grafting – CABG), carotid arteries stenosis simultaneously exists, which is of hemodynamic significance, 60% of patients undergoing carotid endarterectomy (CEA) show signs of angina pectoris and in 18% of cases coronary angiography confirmed a significant degree of coronary disease (11, 12). Patients with a significant coronary stenosis requiring CABG, with a significant simultaneous stenosis of the carotid arteries, are a major therapeu-

tic challenge. The reason for this is primarily the incidence of stroke or cerebrovascular insult (ICV) as one of the most serious CABG complications (13). Numerous studies have shown that the risk of occurrence of ICV during CABG is in direct correlation with the degree of carotid stenosis (14). As a consequence a common strategy for the treatment of such patients was „carotid before coronary" that is, first, an operation on the carotid arteries (CEA) and only then CABG in two parts, or as a simultaneous operation (15). However, in patients with significant stenosis of the main tree of the left coronary artery, „left main stenosis" (LMS) and carotid stenosis, priority is given to CABG, primarily because of the seriousness of the location of the stenosis, the symptoms, the possibility of hemodynamic instability, which is rather frequent in those patients, as well as because of the operation itself.

The main objective of this study was to show the perioperative complications of CABG procedure in surgically treated populations, with and without cardiopulmonary bypass.

Patients and methods

The survey included patients with LMS greater than 50% and carotid artery stenosis greater than 50%, who had undergone CABG at the BH Heart Center in the town of Tuzla, Bosnia and Herzegovina, within the period from May 2009 to May 2014.

Regarding the surgical method, the patients were divided into two groups. Group A consisted of 50 patients who underwent surgery without cardiopulmonary bypass (CPB), and group B 50 patients who had CPB, conformed according to gender, ejection fraction values (group on-pump: 51.5±11.4 and group off-pump 55.2±10.1), EuroSCORE (group on-pump: 3.7±1.5, group off-pump 3.5±1.1), and the number of bypass grafts performed.

These perioperative results in both groups were analyzed and compared: a) total duration of surgery (expressed in minutes); b) time spent on a respirator (expressed in hours); c) time spent in the Intensive Care Unit (ICU) (expressed in hours); d) the amount of postoperative bleeding (expressed in milliliters); e) the amount of compensated blood (expressed in milliliters) f) basic perioperative complications and their frequency (postoperative bleeding requiring revision, atrial fibrillation, myocardial infarction, deep wound infection), which was monitored within the same hospitalization; g) basic postoperative neurological complications (cognitive deficits, transient ischeamic attack (TIA), cerebrovascular insult (ICV) which were monitored within the same hospitalization; and h) length of hospitalization (expressed in days).

Statistical analysis

Distribution of the continuous variables was expressed as the mean ± standard deviation and compared by means of the unpaired two-tailed T-test or the Fisher exact test. Categorical variables were tested by $\chi 2$. Statistical significance was considered as p value less than 0.05.

Results

In both analyzed groups there were no significant differences between either the sexes or average age values, ejection fraction and EuroSCORE. Examination of preoperative risk factors showed that hypertension, hypercholesterolemia, heredity and smoking were most common in both groups. Also, a comparative analysis of the territorial distribution of bypass grafts between the groups showed an insignificant difference in the number of grafts in a particular coronary area.

An analysis of basic perioperative results is given in Table 1.

Analysis of basic perioperative results indicates significant differences between the

groups in the time spent on a respirator, the length of time spent in intensive care, the amount of postoperative bleeding and the amount of compensated blood. The duration of surgery was insignificantly shorter in the off-pump group. Also, the total number of hospitalization days was significantly lower in the off-pump group.

An analysis of the frequency of perioperative complications, such as rhythm disorder, wound infection, bleeding reoperation and myocardial infarction, for both groups is presented in Table 2.

In both groups the most frequent perioperative complication was rhythm disorder as a type of atrial fibrillation, then prolonged bleeding requiring reoperation exclusively in the off-pump group, myocardial infarction, and wound infection was noticed in the on-pump group. Analysis of death frequency in both groups leads to similar conclusions. Mortality insignificantly lower in the off-pump group.

An analysis of the frequency of perioperative complications in terms of cognitive and motility disorders or occurrence of milder cognitive deficits, then TIA and ICV in both groups is presented in Table 3.

The analysis indicates a smaller number of milder cognitive deficites in the off-pump group, also the occurrence of a stroke, noticed only in the on-pump group. In both

Table 1 Perioperative results for both groups

Monitored variables	Group A*	Group B†	p‡
Operation (min; $\bar{x} \pm SD$)	248.0±34.2	237.6±38.2	0.155
Respirator (h; $\bar{x} \pm SD$)	12.1±6.7	9.1±4.2	0.009
Stay in ICU (h; $\bar{x} \pm SD$)	59.5±88.1	31.3±14.9	0.028
Bleeding (ml; $\bar{x} \pm SD$)	584.0±232.8	456.4±168.0	0.002
Blood compensation (ml; $\bar{x} \pm SD$)	358.8±351.7	187.4±253.9	0.006
Total hospitalization (d; $\bar{x} \pm SD$)	8.4±3.5	7.1±2.1	0.033

*Surgery performed on-pump; †Surgery performed off-pump; ‡Two-tailed unpaired student's t-test; ICU=Cardiac intensive care unit.

Table 2 Perioperative complications for both groups

Complication	Group A*	Group B†	p
Rhythm disorder‡, n (%)	17 (34.0)	15 (30.0)	0.668§
Wound infection, n (%)	2 (4.0)	0 (0.0)	0.495‖
Bleeding-reoperation, n (%)	3 (6.0)	0 (0.0)	0.242‖
Myocardial infarction, n (%)	1 (2.0)	2 (4.0)	1.000‖
Mortality, n (%)	3 (6.0)	0 (0.0)	0.242‖

*Surgery performed on-pump; †Surgery performed off-pump; ‡By type of atrial fibrillation; §χ^2 test; ‖Fisher exact test.

Table 3 Neurological complications

Neurological complications	Group A*	Group B†	p‡
Milder cognitive deficit, n (%)	4 (8.0)	3 (6.0)	1.000
TIA, n (%)	4 (8.0)	1 (2.0)	0.362
ICV, n (%)	4 (8.0)	0 (0.0)	0.117
Overall incidence of neurological complications, n (%)	12 (24.0)	4 (8.0)	0.054

*Surgery performed on-pump; †Surgery performed off-pump; ‡Fisher exact test. TIA=Transient ischeamic attack; ICV=Cerebrovascular insult.

groups the most frequent perioperative complication was transitory consciousness disturbance by type of TIA, and mild cognitive deficit. The overall incidence of neurological complications showed a difference in the observed groups in terms of the more frequent occurrence of neurological deficits in the on-pump group.

Discussion

The results indicate the wide benefit of using the off-pump method in our study and bring us to the conclusion that CABG without CPB has certain advantages over the other method, in patients with a combined disease.

Numerous studies have shown that the risk of CVI during CABG is concommitant to the degree of carotid stenosis (14). In distinction from patients without a significant carotid disease in which the incidence of ICV after CABG is only 1.9%, in patients with significant stenosis it increases significantly, so that it was 3% in patients with unilateral stenosis of 50-90%, 5% in patients with bilateral 50-90% stenosis and 7-11% in patients with carotid occlusion (16). Given the well-known fact that for the occurence of ICV during CABG the most responsible are manipulation of the changed atherosclerotic aorta during cannulation, and the clamping necessary to establish the cardiopulmonary bypass (CPB) (17, 18) a logical solution in reducing the incidence of ICV appears to be operations avoiding the use of CPB. That is why CABG without CPB, so-called „beating heart surgery“ could represent an acceptable alternative to conventional CABG with CPB, in order to reduce the incidence of adverse events in patients with significant stenosis of the carotid arteries, which, as is already well-known, have an increased incidence of ICV. However, still today in the technical performance of complex cardiosurgical surgery primacy is given to the use of CPB and data from 2006 show that in the USA only 20% operations were performed on a „beating heart“.

With the increasing ease in the technical performance of surgery, a complete planned revascularization and the quality of bypass grafts performed, the conditions have been created for a comparative analysis of the results obtained with these two operating methods, primarily in high-risk patients who, theoretically, should benefit the most from surgery without CPB.

According to the results shown by Lancey and associates (19) in a sample of 76 patients, matched in terms of preoperative status and with the same surgeon, the choice of surgical technique itself determines the postoperative recovery, primarily in the prolongation of the total duration of mechanical ventilation. This fact is even more significant when the conclusions are added of the study conducted by Natarajan and associates (20) on a group of 470 patients who underwent surgery on CPB, according to which there was a significant difference in the duration of mechanical ventilation between patients with shorter or longer use or duration of CPB itself. Our results indicate similar conclusions. Namely, this study, too, shows a signifficant difference in the time spent on a respirator, that is the time spent on mechanical ventilation was shorter in patients who underwent surgery without CPB. On the other hand, the undoubted influence of CPB was shown in the study by Rosenfeld and associates (21). In 9869 patients divided into two groups, in terms of the length of stay in the ICU, a direct connection with the length of stay on CPB was shown. Patients with a prolonged stay in ICU also experienced 11 additional complications during that stay. The results of our study show that the time spent in ICU is significantly shorter in patients who did not have CPB.

The results of our study also correspond with the majority of studies pointing to the advantage of surgery without CPB related to hospitalization duration. Namely, this study too indicates a significant difference in hos-

pitalization duration in favour of patients who did not have CPB.

Our study also indicates a significantly lower amount of postoperative bleeding in patients who did not have CPB. The amount of postoperatively compensated blood was significantly lower in patients without CPB. A clear conclusion may be drawn that the off-pump method is the best choice in patients with a higher risk of operative and postoperative bleeding and an increased tendency for bleeding. Particularly significant is the group of patients, like the one included in this study, in which it was necessary to perform two surgeries, either simultaneously or with a time interval. Analysis of the overall incidence of postoperative complications in both groups indicates there were fewer in the off-pump group, but without statistical significance. In both groups the most frequent perioperative complication was rhythm disorder in terms of the type of atrial fibrillation, then prolonged bleeding requiring reoperation, solely in the on-pump group, myocardial infarction, and wound infection, noticed exclusively in the on-pump group. Analysis of the frequency of deaths in both groups leads to similar conclusions. The mortality was insignificantly lower in the off-pump group. Following the indicated differences between the groups it was obvious that the incidence of events was lower in the group of patients operated without CPB. In addition we noticed a decreased number of neurological complications in patients operated without CPB. The greatest difference was noticed in the incidence of ICV, which was also lower in patients operated without CPB.

In our study there were no registered cases of ICV in the group of patients operated without CPB, while in the other group, 4 cases of ICV were registered. The overall incidence of cerebrovascular neurological complications wasnot statistically significant. The reason why it is not statistically significant should be primarily sought in the small sample size.

Limitation of the study

This study was performed with a limited number of patients. Patients' comorbidities, such as obesity, previous insults, arterial wall thickness and many others, could possibly have influenced the results. No scale was used for detailed quantification of cerebrovascular neurological complications. Considering the cerebrovascular neurological complications, it is also important to notice the small sample size regarding significant differences.

Conclusions

According to the results of this study we can say that CABG without CPB has certain advantages over surgery using it, in patients with diseases of the coronary and carotid vessels. This is shown by the shorter operation time and the time spent on a respirator, the shorter stay in the ICU, as well as the shorter overall hospitalization time, the smaller amount of postoperative bleeding and blood compensation. The off-pump cardiac surgical method of treatment of angiopatic diseases of coronary and carotid blood vessels proved to be probably the better treatment method. The same method undoubtedly resulted in a statistically significant shorter stay on the mechanical ventilation regime in patients operated without CPB, a shorter stay in ICU, as well as in overall hospitalization duration and in the amount of bleeding and compensation of blood and blood derivatives. It turned out that other basic perioperative results were better in the patients operated without CPB, although without a statistically significant value. Also, the presumption that the frequency of neurological complications would be lower in patients operated without CPB proved true, even this is probably not statistically valid because of the sample size.

What is already known on this topic

Patients with a significant coronary disease requiring CABG, with a significant simultaneous stenosis of the carotid arteries, are a major therapeutic challenge, mainly because of the incidence of stroke or cerebrovascular insult as one of the most serious cardac surgical complications. It is well known strategy to perform surgery „carotid before coronary" usually in two phases, or as a simultaneous operation, however, in patients with significant stenosis of the main tree of the left coronary artery (left main stenosis – LMS) priority is given to CABG.

What this study adds

This study clarifies the perioperative complications of the CABG procedure with and without cardiopulmonary bypass. The results indicate significant differences between the groups in the time spent on a respirator or time in the ICU, and the amount of postoperative bleeding or compensated blood. The overall incidence of neurological complications showed a difference between the observed groups. CABG without CPB has a number of advantages over the other method.

Conflict of interest: The authors declare that they have no conflict of interest.

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