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Our Initial Results of Off-pump Coronary Artery Bypass Grafting

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Background. On-pump coronary artery bypass grafting (CABG) remains a procedure of choice in patients with ischemic heart disease despite nearly two decades of utilization of off-pump techniques. Nearly all aspects of off-pump CABG operations are still debatable, including indications and contraindications to this procedure. We report here our initial experience with routine application of off-pump CABG in patients with ischemic heart disease.

Methods. Results of 96 off-pump CABG procedures performed from May 2015 to date are analyzed. Preoperative demographic and clinical data, intraoperative data and results of postoperative course are analyzed. Our results are compared with the results of other authors and mortality rates are compared to predicted by risk-stratification system "EuroScore" values.

Results. The mean number of distal anastomoses was 3.01 +/- 0.07 per patient. In 75 (78.1%) patients we constructed 3 or more grafts, in 22 cases (23%) - we used complex types of surgical technique (sequential, "Y-graft" or "T-graft"). 28 (29.2%) patients required inotropic support in ICU for initial recovery with an average duration of 3.14 +/- 0.74 hours. In 3 (3.1%) patients in the postoperative period were episodes of sustained atrial fibrillation. In 1 (1.04%) patient course of OPCABG procedure was complicated with emergent conversion to on-pump CABG. Mortality was 1.04% (1 patient).

Conclusions. A modern OPCABG approach offers low mortality, excellent clinical outcomes, and does not come at the price of less complete revascularization.

Keywords: coronary artery disease, myocardial revascularization, off-pump coronary artery bypass grafting

Introduction

The first coronary artery bypass grafting (CABG) procedures performed in the 60s - 70s of the past century were the operations on the beating heart without using cardiopulmonary bypass (CPB) and cardioplegia (CP) [1, 2]. However, the universal spread and popularity acquired performing CABG using CPB-machine – so-called on-pump CABG, popularized by Favaloro and colleagues [3]. Very soon this technique became very popular and demonstrated the possibility of performing these operations on the motionless and bloodless operative field, as well as the ways of its standardization, widespread dissemination and training. Several decades of performing CABG operations on-pump revealed a number of complications associated directly with cardiopulmonary bypass itself and cardioplegia, as well as with connecting the patient to the heart-lung machine (cannulation of the great vessels) and clamping of the aorta. Consequently, many eyes were again turned to the possibility of performing coronary bypass surgery on the beating heart without CPB and cardioplegia (off-pump CABG or OPCABG), which also falls into the category of minimally invasive cardiac surgery [4].

However, despite of the nearly two decades of utilization and numerous reports, this method remains not standardized, its use is not reflected in the leading American and European guidelines, indications and contraindications for these operations are not specified. Most of the issues related to the OPCABG procedure remains debated [4]. In this regard, we would like to present our initial experience with using OPCABG in the newly created surgical department.

Material and Methods

Since the beginning of our activity in May 2015 we have operated on 110 patients with coronary artery disease who underwent 110 isolated OPCABG procedures (Table 1). In 5 cases (4.5%) operations were performed with CPB and cardioplegia (conventional on-pump CABG). In 9 cases (8.2%) operations were performed with CPB on a beating heart ("on-pump beating heart"). In 96 patients (87.3%) procedures were performed without CPB – off-pump CABG or OPCABG.

The average age of patients was 59.14 +/- 0.4 years (range from 33 to 77 years). 45 patients (46.9%) were older than 60 years. Most of our patients were male (79 patients, representing 82.3% of all population). The vast majority of patients - 81 (92%) - were in the III-IV NYHA functional class. Factors such as obesity, diabetes and chronic obstructive pulmonary disease (COPD) occurred in 39 (40.6%), 28 (29.2%) and 26 (27.1%) of the operated patients respectively. Also, in 28 cases (29.2%) there were carotid artery lesions of varying degree. In 4 (4.2%) patients there was renal failure not requiring hemodialysis.

It should be noted that 63 patients (65.6%) had a history of myocardial infarction. Most of the patients who have suffered myocardial infarction had 1 MI in anamnesis - 47 (74.6% of patients with previous MI). Another 12 patients (19%) had a history of 2 MI and 3 patients (4.8%) had 3 MI. 11 patients (11.5%) had a history of previous PCI with stenting of coronary arteries. It should be noted that t46 patients (47.9%) were with acute coronary syndrome, including 13 (13.5%) with acute phase of myocardial infarction. Angiographic picture in the vast majority of patients was characterized by high complexity of coronary lesions. So, 76 patients (79.2%) had three-vessel coronary disease, and 17 (17.7%) – two-vessel disease. Left mainstem disease (or its equivalent) was noted in 43 (44.8%) patients. Although the incidence of stenotic lesions was similar in all three regions, distribution of occlusive vascular lesions was uneven. So, most frequently were observed occlusions of the left anterior descending artery (LAD) and right coronary artery (RCA) distributions – they were registered in 45.7% and 42.9% respectively, while the occlusive lesions in the circumflex artery (Cx) artery area were met less frequently - in 21.7% of cases.

According to preoperative echocardiography, signs of left ventricular dilatation were observed in 26% of patients – LVEDD of more than 60mm was in 23 (23.9%) patients, and the LVEDD>70 mm – was in 2 patients (2.1%). 33.3% of patients had a decrease in LVEF. For instance, LVEF<50% was in 27 (28.1%) patients, and less than 40% was observed in 5 (5.2%).

Table 1. Preoperative demographics and clinical data

Variable	n (96)	%
Age (mean), years	59,14 +/- 0,4 (33-77)	
Older than 60 years	45	46,9%
Male	79	82.3%
Female	17	17.7%
FC III NYHA	78	88.6%
FC IY NYHA	3	3.4%
Obesity	39	40,6%
COPD	26	27,1%
Diabetes	28	29,2%
Renal failure	4	4,2%
History of MI	63	65,6%
1 MI	47	74,6%
2 MI	12	19%
3 MI	3	4,9%
PCI, stenting in anamnesis	11	11,5%
Acute coronary syndrome	46	47,9%
Acute MI	13	13,5%
3-vessel disease	76	79,2%
2-vessel disease	17	17,7%
Left mainstem disease (or its equivalent)	43	44,8%
Echo LVEDD>60 mm	23	23,9%
EchoLVEDD>70 mm	2	2,1%
LVEF <50%	27	28,1%
LVEF <40	5	5,2%
Urgent procedure	15	15,6%
EuroScore mean (logistic)	3,69 +/- 0,27	
EuroScore mean (percent)	3,85 +/- 0,43%	

20% of patients had I-II degree of mitral insufficiency.

In 15 patients (15.6%) operation had urgent status.

The risk of surgical intervention predicted by risk-stratification system "EuroScore" averaged 3.69 +/- 0.27 (logistic) or 3.85 +/- 0.43% (by percentage).

Surgical Technique

All operations were carried out through median sternotomy. We also routinely used high thoracic epidural anesthesia with bupivacaine in combination with a conventional general anesthesia. Standard monitoring technique was used in all cases.

Internal thoracic artery (ITA) was harvested whether skeletonized without opening of the left pleural cavity or pedicled the opening of the left pleural cavity, depending on the preferences

Table 2. Intraoperative data

Variable	n (96)	%
Operation times, min	263,8 +/- 5,4	
(160-460)		
Blood loss, ml	597 +/- 24,49	
Usage of internal thoracic artery	95	98,9%
Mean number of distal anastomoses per patient	3,01 +/- 0,07	
3 grafts	75	78,1%
4 grafts	20	20,8%
Sequential technique	11	11,5%
Complex conduits (Y-graft, T-graft)	11	11,5%
"Internal thoracic artery-LAD first" technique	72	75,8%
"Other vessel first" technique	24	24,2%
Conversion to CPB	1	1,04%

Table 3. Postoperative data

Variable	n (96)	%
Conversion to CPB	1	1,04%
Need for inotropic support	28	29,2%
Inotropic support time, hours	3,14 +/- 0,74	
Ventilation time, hours	5,78 +/- 0,37	
Prolonged ventilation (>24 hours)	1	1,04%
Atrial fibrillation	3	3,1%
RBC transfusikon, ml	358,43 +/- 19,7	
FFP transfusion, ml	410,71 +/- 16,63	
Length of stay in ICU, hours	47,8 +/- 1,8	
Length of stay in hospital after surgery, days	6,83 +/- 0,3	
Chest re-open for hemostasis	2	2,08%
Superficial wound infection	1	1,04%
Mortality	1	1,04%

of the operating surgeon. Heparin was administered at the dose of 1.5 mg/kg of patient weight. Opening the pericardium was performed in a standard inverted "T" fashion. For the positioning of the heart, we used a deep pericardial stitch (Lima-stitch), by manipulation of which we had access to different surfaces of the heart. Also, sometimes for better visualization of the arteries of the Cx artery area we put additional deep pericardial sutures on the left edge of the pericardium near left pulmonary veins. Also we actively changed operating table positions to assist in heart positioning (Trendelenburg position with turns to the left and to the right to visualize different areas of the heart). To stabilize the myocardium, we used the commercially available tissue stabilizers (Octopus 4 Tissue Stabilizer; Medtronic, Minneapolis, MN). Additionally, a mister-blower (Guidant, Indianapolis, IN) was used. For temporary occlysion of revascularized vessel we used silicone vessel loops. Coronary arteriotomy was performed with a beaver blade, and shunt insertion (ClearView Intracoronary Shunt; Medtronic) was used whenever possible.

Myocardial revascularization we always started with occluded and collaterilized artery (in half of the cases it was the LAD, in other half - RCA). If it was LAD – we constructed anastomosis with internal thoracic artery. Then, the operation proceeded in a standard fashion. If the occluded artery was RCA - then first we anastomosed safenous vein to the RCA or PDA, then constructed the proximal anastomosis of that vein to the ascending aorta (as well as other proximals if other arteries were planned to be grafted). Then we continued with ITA-LAD distal anastomosis and other distals with other arteries (DV, OM etc.). If there was no occluded arteries, myocardial revascularization was always started with anastomosis of the ITA with LAD. Prior to arteriotomy we always performed a short period (30 seconds) of ischemic preconditioning using silicone vessel loop. Anastomoses of the ITA and sequential anastomoses were constructed using polypropylene 8/0 suture, the remaining distal anastomoses - polypropylene 7/0 sutures. For the construction of proximal anastomoses we used polypropylene 6/0 suture. Upon completion of the revascularization, if there were no excess bleeding, we neutralized only half the dose of heparin.

Results

In 95 patients the ITA was used (98.9%).The mean number of distal anastomoses was 3.01 +/- 0.07 per patient (range 1 to 5 grafts). In 75 (78.1%) patients we constructed 3 or more grafts (Table 2): in 55 (57.3%) were grafted 3 vessels, and in 20 (20.8%) patients - 4 vessels. In 22 cases (23%) - we used complex types of surgical technique: in half of the cases (11 patients) we used sequential technique, when with one conduit two or more vessels were revascularized, and in the remaining 11 (11.5%) patients were constructed complex conduits - in the form of a "Y-graft" or "T-graft".

In 72 (75.8%) patients initially ITA-LAD anastomosis was constructed first followed by other coronary areas. In the remaining 24.2% of cases other regions were revasculaized first followed by ITA-LAD anastomosis.

Mean operative time was 263.8 +/- 5.4 minutes (160-460 minutes). Blood loss on the average was 597.06 +/- 24.49 mL (300-1500 mL).

28 (29.2%) patients required inotropic support in ICU for initial recovery with an average duration of 3.14 +/- 0.74 hours (Table 3). Duration of ventilation support (respiratory support) after surgery was 5.78 +/- 0.37 hours. Prolonged ventilation (more than 24 hours) was needed in 1 (1.04%) patient.

In 3 (3.1%) patients in the postoperative period were episodes of sustained atrial fibrillation (AF), which were treated

(managed) pharmacologically. Red blood cell (RBC) transfusions averaged 358.43 +/- 19,7ml/patient during surgery and in surgical intensive care unit (ICU), and fresh frozen plasma (FFP) transfusuions reached on average - 410.71 +/- 16.63 ml/patient.

Mediastinitis and other wound infection problems after surgery were not registered. In 1 (1.04%) patient there was superficial wound infection without any serious consequences. In 2 (2.08%) patients due to bleeding chest reopening for hemostasis was performed.

In 1 (1.04%) patient course of OPCABG procedure was complicated with emergent conversion to on-pump CABG due to uncontrollable outbreak of arrhythmias. In this case operation was continued on-pump beating heart with good postoperative results.

One patient (1.04%) died due to malignant cardiac arrhythmias on the third postoperative day.

Discussion

We present our consecutive series of patients operated by our group and reflecting our daily practice. The complexity of our population is demonstrated by the large number of patients with comorbidities and other risk factors as obesity, COPD and diabetes, as well as the presence of other important factors, as a left mainstem (LM) lesions, combined lesions of the carotid vessels, the high proportion of multivessel coronary disease etc. Also an important factor was the fact that about half of our patients preoperatively were clinically unstable (acute coronary syndrome, acute phase of myocardial infarction). But in contrast to other author's data, we did not have patients with redo heart surgery or with preoperatively inserted intra-aortic balloon counterpulsator [5,6].

The proportion of patients with LM disease (or its equivalent) was 44,8%. W.Turner et al [5] in their first series of 100 patients report about 3% of patients with LM-disease, though at the same period proportion of such patients in STS registry was about 15%. According to M.Y. Emmert [7], of the 983 patients 343 were with LM lesions, which accounted for 34.9% of the operated. Close to our data, the proportion of patients with left main stem lesion reported by Ki-Bong Kim et al (8) - of 1345 operated in 9 years 42.2% had LM disease or three-vessel coronary lesions. Very low rate of such patients in our opinion could talk about patient selection (or selection bias).

The main argument, which opponents of OPCABG put – is performing off-pump CABG procedures at the expense of completeness of revascularization. Thus, a low number of distal anastomoses per patient can talk about patient selection (selection bias), or actual incomplete myocardial revascularization. For example, in our series of operated patients, the mean number of distal anastomoses was 3.01 +/- 0.07 per patient. Given the presence of patients with two- and three-vessel disease, this figure seems to us high enough to demonstrate the adequacy and completeness of revascularization. As another example, in W.Turner [5] series of 100 OPCABG mean number of distal anastomoses per patient was 1.9, in E.Buffalo [6] series - 1.9 and M.Y.Emmert et al [7] report - 3.62 anastomoses/patient.

Another indicator of the success of implementation of CABG operations on the beating heart is the rate of conversion to CPB. Thus, according to the different authors [9-11], it ranges from 1% to 15%, with an average of 3-4%. In our series of patients conversion rate was 1.04% (1 patient converted to on-pump beating heart CABG due to arrhythmic complications). It is believed that the most common cause of complications, causing the emergent intraoperative conversion is local ischemia, thus, global ischemial accompanying cardioplegic cardiac arrest in such patients may lead to catastrophic heart failure [4, 6, 11]. In this connection, the authors recommend at conversions on CPB, to continue the operation on-pump beating heart in order not to aggravate ischemic state of the myocardium [4].

In general, among our initial series of 110 patients with isolated ischemic heart disease, 87.3% of CABG surgeries were performed off-pump. Thus, by different authors reports, this parameter ranges from 49% to 99% [4-6, 10, 11], and exploring various approaches of different groups can also shed light on additional anesthetic, surgical and technical aspects of the problem.

One of the most common complications that occur after conventional CABG is an episode of atrial fibrillation, which complicates the postoperative period in approximately 30-45% of patients. In our series of operations we registered three patients (3.1%)with this complication, which is quite a low figure, demonstrating the effectiveness of OPCABG surgery. According to the RA Archbold et al [12] paroxysms of atrial fibrillation observed in 4% -26% of all operated off-pump CABG patients. As you can see, our findings fit into the overall picture of the post-operative course after OPCABG surgery.

And finally, the mortality rate we observed was 1.04% (1 patient) – in contrast to the expected by the EuroScore risk-stratification system which was 3,85 +/- 0,43% [13]. According to Ki-Bong Kim et al [8] in the 1345 operated patients mortality rate was 1,6%, to W.Turner et al [5] - 3% of 100 operated patients, E.Buffalo [6] – reported about 1.9 % mortality on 3866 patients operated and M Y.Emmert [7] observed 2.2% mortlity. One can see that our mortality rate was close to the range of other group reports.

Study limitations

Of course, this is a retrospective and observational study and all associated disadvantages apply. An ideal approach would be a trial of prospective and randomized nature. Next, our results lack the force of numbers, and certainly a higher level of significance may have been obtained had we analyzed a larger cohort of patients. However, we present a homogenous population with a 100% standardized and modern approach to OPCABG. This approach is supported by at least 90% of CABG cases being done in off-pump fashion currently, which is far above the international standard, and also by our excellent overall outcome as well as our overall low conversion rate to CPB.

Conclusion

The isolated off-pump CABG surgery is a safe alternative that provides low rates of complications and mortality, rapid clinical recovery and rehabilitation of patients without compromising the adequacy of myocardial revascularization.

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