# RESULTS OF FLOWMETRIC ASSESSMENT OF COMPOSITE Y-GRAFTS AND AUTOVENOUS CORONARY ARTERY BYPASS GRAFTS

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*Objective. The purpose of the study was to perform intraoperative assessment of blood flow in coronary bypass grafts of the «first» and «third» order according to Calafiore A.M. with the help of the TTFM technique and to compare the obtained results.*

*Patients and methods. This retrospective, single-centre study enrolled a total of 222 patients subjected to coronary artery bypass grafting (CABG) from January to November 2017. Depending on the type of bypass grafting of the posterior interventricular artery (PIVA), the patients were divided into 2 groups. Group One consisted of 108 patients undergoing bypass grafting of the PIVA with the help of combined Y-grafts from the right internal thoracic artery (RTIA). Group Two was composed of 114 patients subjected to autovenous coronary artery bypass grafting of the PIVA. Blood flow was assessed with the help of the VeriQ MediStim® flowmeter after termination of extracorporeal circulation (ECC), at systolic pressure of 100–110 mm Hg. The parameters of blood flow were assessed using the 1.5- and 2-mm probes. In a specially designed protocol we registered the type of the shunt, the bypassed artery, and values of flowmetry parameters. We also evaluated the pattern of the flowmetric curve according to Takemi Handa et al.*

*Results. The obtained findings revealed a statistically significant difference in the values of $Q_{mean}$ ($p=0.001$), with the PI values in the groups not statistically differing ($p=0.14$). Thus, in patients with similar parameters influencing the volumetric velocity of blood flow (the degree of proximal stenosis, diameter of the bypassed artery, mean systolic AP and HR) the value of $Q_{mean}$ was higher in the group with coronary artery bypass grafting (CABG), i. e., in the group of the «first-order» conduits. Therefore, an autovein directly anastomosed to the aorta experiences grater haemodynamic overload, which completely confirms the theory of Calafiore A.M.*

*Conclusions. First-order conduits (CABG) appear to experience greater wall strain because of greater haemodynamic overload as compared with third-order conduits (Y-grafts). A composite Y-graft may be an alternative technique of bypass grafting of the basin of the right coronary artery (RCA). A composite Y-graft has greater resistance to wall shear stress than an autovein anastomosed to the aorta.*

***Key words:*** *first- and third-order conduits, composite Y-graft, wall strain, wall shear stress, flowmetry.*

## INTRODUCTION

Numerous randomised studies have demonstrated advantages of using both internal thoracic arteries (ITA) in revascularization of the territory of the left coronary artery (LCA). However, the question concerning the method of bypass grafting of the right coronary artery (RCA) in a triple-vessel lesion remains open [1]. Other authors, however, report comparable and even better results of using an autologous vein [2, 3]. There is an opinion that one of the causes of incompetence of an autovenous graft is a haemodynamic injury sustained by the wall of a conduit directly anastomosed to the aorta. In his article Calafiore A.M. graded the grafts depending on the source into the first- and third-order conduits [4]. The author claims that in first-order conduits anastomosed to the aorta the shear stress wave increases which may lead to distension of the walls, intimal rupture and consequently to the development of early hyperplasia and occlusion. In the available literature we failed to find either confirmation or denial of this theory.

Specialists of the Federal Centre of Cardiovascular Surgery worked out and implemented into clinical practice an alternative technique of bypass grafting of the right coronary artery (RCA) and its branches. The use of contemporary methods of intraoperative assessment of coronary bypass grafts will allow us to determine the consistency of this theory.

Objective. The purpose of the study was to carry out intraoperative assessment of blood flow in first- and second-order coronary grafts according

*Table 1*

**Clinical and demographic characteristics of patients**

| Parameter | Y-grafts n=108 | 95% CI | CABG n=114 | 95% CI | p |
|---|---|---|---|---|---|
| BMI | 28.9±4.2 | 28.1–29.7 | 29.6±4.7 | 28.7–30.5 | 0.24 |
| Age, years | 61.4±8.4 | 59.8–63 | 61.1±8.2 | 59.6–62.6 | 0.78 |
| Women, n | 24 | 22 (15.4–30.1) | 24 | 21 (14.6–29.4) | 1.0 |
| CCS II, n | 39 | 36 (27.7–45.5) | 48 | 42 (33.4–51.2) | 0.18 |
| CCS III–IV, n | 69 | 64 (54.5–72.3) | 66 | 58 (48.7–66.5) | 0.63 |
| NYHA FC II, n | 45 | 42 (32.8–51.1) | 51 | 44 (35.9–53.8) | 0.37 |
| NYHA FC III, n | 63 | 55 (48.9–67.2) | 63 | 55 (46.1–64.1) | 1.0 |
| DM, n | 27 | 25 (17.8–33.9) | 24 | 21 (14.6–29.4) | 0.61 |
| COPD, n | 12 | 11 (6.4–18.4) | 12 | 10 (6.1–17.5) | 1.0 |
| AF, n | 12 | 11 (6.4–18.4) | 18 | 15 (10.2–23.6) | 0.21 |
| EF, % | 48.5±10.8 | 46.4–50.5 | 50.9±9.7 | 49.1–52.7 | 0.82 |
| Syntax score | 33.1±11.9 | 30.8–35.3 | 30.7±9.6 | 28.9–32.5 | 0.98 |
| Days in ICU | 3.2±1.2 | 2.9–3.4 | 3.0±0.8 | 2.8–3.1 | 0.14 |

*Abbreviations: BMI – body mass index; CCS – Canadian Cardiovascular Society grading of angina; AMI – acute myocardial infarction; DM – diabetes mellitus; COPD – chronic obstructive pulmonary disease; AF – atrial fibrillation; EF – ejection fraction; ICU – intensive care unit; CI – confidence interval; p – standard deviation.*

*Table 2*

**Angiographic and intraoperative characteristics of the bypassed arteries**

| | Y-grafts | 95% CI | CABG | 95% CI | p |
|---|---|---|---|---|---|
| Diameter, mm | 1.66±0.26 | 1.61–1.71 | 1.71±0.25 | 1.66–1.76 | 0.14 |
| 80–89% proximal stenosis of the RCA, n | 21 | 19 (13.1–27.9) | 30 | 26 (19.1–35.1) | 0.13 |
| 90–100% proximal stenosis of the RCA, n | 87 | 80 (72.1–86.9) | 84 | 74 (64.9–80.9) | 0.53 |

*Abbreviations: RCA – right coronary artery; CABG – coronary artery bypass grafting; CI – confidence interval.*

to Calafiore A.M. with the help of the TTFM technique and to compare the obtained results.

## PATIENTS AND METHODS

This retrospective, single-centre study enrolled a total of 222 patients subjected to coronary artery bypass grafting (CABG) from January to November 2017. Depending on the type of bypass grafting of the posterior interventricular artery (PIVA), the patients were divided into 2 groups. Group One consisted of 108 patients undergoing bypass grafting of the PIVA with the help of combined Y-grafts from the right internal thoracic artery (RTIA). Group Two was composed of 114 patients subjected to autovenous coronary artery bypass grafting of the PIVA. The clinical and demographic characteristics of the patients of both groups are shown in Table 1.

In all patients the surgical approach was performed through the median sternotomy. The operations were carried out in conditions of extracorporeal circulation (ECC). Custadiol® was used as a cardioplegic solution. The veins were harvested by means of the no-touch technique, which avoids spasms and the need for distension of the conduit and preserves the vein's cushion of perivascular fat [5]. The PIVA was bypassed in all patients. Bypass grafting of the arteries of the LCA territory of the LCA was carried out in accordance with the lesion of its bed. The formation of composite Y-grafts was performed using polypropylene thread 8/0 between the proximal third of the right internal thoracic artery (RITA) and an autologous vein in an end-to-end manner. The formation of the anastomosis was followed by creating a window with a T-shaped incision in the pericardium 2–3 cm above the diaphragmal nerve. In this way the composite Y-graft was directed linearly to the posterior wall of the heart, repeating the course of the posterior interventricular artery (PIVA) in the distal segment. The formation of distal anastomoses was performed using monofilament polypropylene thread 8/0, that of proximal ones using thread 6/0 in conditions of parallel ECC.

The blood flow was evaluated with the help of the VeriQ MediStim® flowmeter after termination of extracorporeal circulation (ECC), at systolic pressure of 100–110 mm Hg. The following parameters of the blood flow were assessed:

1. Average volumetric blood flow velocity ($Q_{mean}$);
2. Pulsatility index (PI);
3. Diastolic volumetric blood flow fraction (DF).

The parameters of blood flow were assessed using the 1.5- and 2-mm probes. In a specially designed protocol we registered the type of a bypass graft, the artery bypassed, and the values of flowmetry parameters. We also evaluated the pattern of the flowmetric curve according to Takemi Handa, et al. [6].

## RESULTS

According to the findings of coronary angiography (CAG), the patients of both groups were found to have the right type of blood supply. The degree of proximal stenosis varied from 80 to 100%. The angiographic and intraoperative characteristics of the patients are presented in Table 2.

No statistically significant differences in either the diameter of the bypassed artery or the degree of the proximal stenosis in the examined groups were revealed.

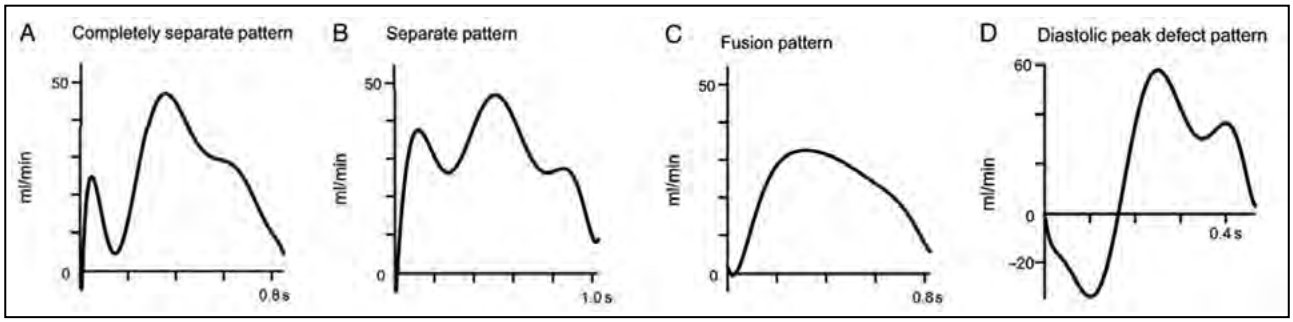


Fig. Patterns of flowmetric curves according to Takemi Handa, et al. [6]

*Table 3*

**Results of flowmetric assessment of CABG**

| Parameters | Y-grafts n = 108 | 95% CI | CABG n = 114 | 95% CI | p |
|---|---|---|---|---|---|
| PI | 1.9±0.5 | 1.8–1.9 | 1.8±0.5 | 1.7–1.8 | 0.14 |
| $Q_{mean}$ | 40.1±15.8 | 37.1–43.1 | 55.1±18.6 | 51.6–58.5 | 0.001 |
| DF | 69.5 | 64 (54.9–72.7) | 74 | 65 (55.8–73.1) | 0.41 |

*Abbreviations: PI – pulsatility index; $Q_{mean}$ – average volumetric velocity of blood flow; DF – conduit's diastolic filling fraction.*

Analysing the flowmetry curve patterns demonstrated that the flow curves in the examined groups predominantly belonged to type A and B according to the classification of Takemi Handa, et al. [6] (Fig.). No changed patterns of flowmetric curves (type C and D) were revealed.

The severity of proximal stenosis, as well as the degree of manifestation of the distal bed appear to have a direct effect on volumetric velocity of blood flow. The absence of statistically significant differences in the groups strongly suggested equal conditions of functioning of the coronary grafts. We carried out flowmetric assessment of blood flow in the CABG. The results are shown in Table 3.

The obtained findings demonstrated statistically significant difference in the values of $Q_{mean}$ (p=0.001), with the PI values in the groups statistically not differing (p=0.014). Thus, in patients with similar parameters influencing the volumetric velocity of blood flow (degree of proximal stenosis, diameter of the shunted artery, average systolic blood pressure and heart rate) the value of the $Q_{mean}$ was higher in the group with CABG – in the group of the "first order" conduits. Consequently, an autologous vein directly anastomosed to the aorta is subject to greater haemodynamic overload, which fully confirms the theory of Calafiore A.M.

## DISCUSSION

Long-term results of CABG significantly improved with the use of two internal ITAs, which resulted in superiority of multiarterial bypass grafting. However, in case of a triple-vessel lesion important remains the search for an optimal conduit for the RCA's basin. The use of an autologous vein is very common. It is known that in early terms of follow up the competence of autovenous and autoarterial conduits does not differ. However, with time arterial conduits demonstrate their superiority over venous bypass grafts [7], and this fact has some explanations. One of them is discrepancy of the width of the wall of an autologous vein and the grafted coronary artery. A second and the main cause consists in that a conduit anastomosed to the aorta is a "first-order" conduit according to Calafiore A.M. and experiences permanent haemodynamic overload. Whereas the ITA is a third-order branch and is in physiological conditions. The wall of a conduit anastomosed to the aorta experiences tension described in the literature as wall strain, or wall shear stress [8]. In them, the wave of pressure increases, which may lead to dilatation of walls with intimal rupture followed by the development of early intimal hyperplasia. In their theory, Ivanova O.V. et al. determine the value of the wall shear stress (WS), using a modified formula of V.M. Khayutin, which is as follows:

$$\mathbf{HC=4\ BK\ x\ Q_{max}/D,}$$

where BV stands for blood viscosity, $Q_{max}$ is the peak systolic velocity, and D is the conduit's diameter.

As can be seen from this equation, the value of SW depends on the volumetric velocity of blood flow, blood viscosity, and the diameter of the grafted artery. This theory confirms our results, where except for the $Q_{max}$ value all the remaining components of the formula have similar values [9]. Proceeding from this, it is appropriate to use a scheme of bypass grafting, where conduits are less exposed to wall shear stress, which may have place in a composite graft from the RITA.

Apart from resistance to the wall shear stress, the presence of the valvular apparatus in an autologous vein makes it possible to compensate the retrograde flow. Hence, the blood flow in a coronary artery has a unidirectional pattern. This is evidenced by satisfactory parameters of flowmetry ($Q_{mean}$=40.1±15.8 and PI=1.9±0.5) obtained in assessment of composite Y-grafts [10, 11].

The immediate results of this variant of CABG are encouraging. However, it is necessary to carry out assessment of the competence of composite Y-grafts in the remote period.

## CONCLUSIONS

1. First-order conduits (CABG) appear to experience greater wall stress due to greater haemodynamic overload as compared with third-order conduits (Y-grafts).

2. A composite Y-graft may by an alternative technique of bypassing the RCA's territory.

3. A composite Y-graft turned out to possess greater resistance to wall shear stress than an autovein anastomosed to the aorta.

***Conflict of interest: none declared.***

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