УДК 616.132.2-089.819

DOI: https://doi.org/10.17816/PAVLOVJ60221

Опыт применения внутриаортальной баллонной контрпульсации как сопровождения коронарного шунтирования и коронарного стентирования у пациентов со сниженной фракцией выброса левого желудочка и митральной регургитацией ишемического генеза

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АННОТАЦИЯ

Введение. Наиболее частой причиной ишемической дилатации левого желудочка (ЛЖ) является длительно существующий атеросклероз коронарных артерий (КА). Золотым стандартом лечения таких пациентов является коронарное шунтирование с протезированием/пластикой митрального клапана. В качестве предоперационной подготовки больных с данной патологией используется установка внутриаортальной баллонной контрпульсации (ВАБК).

Цель. Анализ изменения степени митральной регургитации (МР) ишемического генеза и клинических исходов у больных со сниженной фракцией выброса (ФВ) ЛЖ и мультисосудистым поражением коронарных артерий на фоне применения ВАБК в сопровождении коронарного шунтирования и коронарного стентирования.

Материалы и методы. В статье представлены результаты лечения 186 больных с митральной недостаточностью ишемического генеза, которым была выполнена ВАБК в качестве предоперационной подготовки в связи с низкой ФВ ЛЖ. Пациенты были разделены на 2 группы. В 1-ую группу вошли 132 пациента, которым было выполнено коронарное шунтирование. Во 2-ую группу вошли 54 пациента, которым было выполнено стентирование коронарных артерий. На основании эхокардиографических данных изучена динамика МР и ФВ ЛЖ до и после реваскуляризации миокарда ЛЖ.

Результаты. В 1-ой группе на фоне применения ВАБК отмечено снижение степени МР на 58% ($p < 0,05$) в раннем послеоперационном периоде (на основании измерения vena contracta (v.c., ширина струи регургитации на клапане) и на 54% ($p < 0,05$) — в срок более 6 мес. после оперативного лечения. Во 2-ой группе на фоне применения ВАБК отмечено статистически значимое снижение степени МР (на основании v.c.) на 42% ($p < 0,05$) в раннем послеоперационном периоде и на 41% ($p < 0,05$) — в срок более 6 мес. после оперативного лечения.

Заключение. Использование ВАБК у пациентов с низкой ФВ ЛЖ, умеренной и выраженной МР, а также значимой патологией коронарных артерий позволило снизить продолжительность оперативного лечения и времени использования искусственного кровообращения путем отказа от необходимости выполнения коррекции митральной недостаточности как непосредственно во время хирургической реваскуляризации, так и в отдаленном периоде (более 6 мес.).

Ключевые слова: *ишемическая митральная недостаточность; реваскуляризация; фракция выброса левого желудочка; внутриаортальная баллонная контрпульсация; ишемическая болезнь сердца*

Для цитирования:
Костямин Ю.Д., Михайличенко В.Ю., Базиян–Кухто Н.К., Греков И.С. Опыт применения внутриаортальной баллонной контрпульсации как сопровождения коронарного шунтирования и коронарного стентирования у пациентов со сниженной фракцией выброса левого желудочка и митральной регургитацией ишемического генеза // Российский медико-биологический вестник имени академика И.П. Павлова. 2021. Т. 29, № 3. С. 419–426. DOI: https://doi.org/10.17816/PAVLOVJ60221

Рукопись получена: 07.02.2021 **Рукопись одобрена:** 06.09.2021 **Опубликована:** 30.09.2021

ЭКО•ВЕКТОР

DOI: https://doi.org/10.17816/PAVLOVJ60221

Experience of using intra-aortic balloon counterpulsation during coronary bypass surgery and coronary stenting in patients with reduced left ventricular ejection fraction and mitral regurgitation of ischemic genesis

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ABSTRACT

INTRODUCTION: The most common cause of ischemic dilatation of the left ventricle (LV) is long-standing atherosclerosis of the coronary arteries (CA). The gold standard for treating such patients is coronary artery bypass surgery with prosthetics/plasty of the mitral valve. For preoperative preparation of patients with such pathology, intra-aortic balloon counterpulsation (IABC) support is used.

AIM: To analyze the changes in the degree of mitral regurgitation (MR) of ischemic origin and of clinical outcomes in patients with reduced left ventricular ejection fraction (LVEF) and multi-vascular coronary artery disease during use of IABC.

MATERIALS AND METHODS: The results of the treatment of 186 patients with ischemic mitral insufficiency who underwent intra-aortic balloon counterpulsation as a preoperative preparation in connection with a low LVEF were outlined in this manuscript. The patients were divided into 2 groups. Group 1 included 132 patients who underwent coronary bypass surgery while Group 2 included 54 patients who underwent coronary artery stenting. The dynamics of MR and LVEF before and after left ventricular revascularization were studied on the basis of echocardiographic data.

RESULTS: In group 1, there was a decrease in the degree of mitral regurgitation by 58% using IABC ($p < 0.05$) in the early postoperative period (based on the measurement of vena contracta, v.c., the width of the regurgitation jet on the valve), and by 54% ($p < 0.05$) in more than 6 months following surgical treatment. In group 2, there was a significant decrease in the degree of MR (based on v.c.) by 42% ($p < 0.05$) in the early postoperative period and by 41% ($p < 0.05$) in more than 6 months following surgical treatment.

CONCLUSION: The use of intra-aortic balloon counterpulsation in patients with low LVEF, moderate and severe MI, and with significant coronary artery pathology, led to the reduction in the duration of surgical treatment and the time of using artificial blood circulation through by excluding the need for the correction of MI, both directly during surgical revascularization and in the long-term period (more than 6 months).

Keywords: *ischemic mitral insufficiency; revascularization; left ventricular ejection fraction; intra-aortic balloon counterpulsation; ischemic heart disease*

For citation:
Kostyamin YuD, Mikhaylichenko VYu, Baziyan–Kukhto NK, Grekov IS. Experience of using intra-aortic balloon counterpulsation during coronary bypass surgery and coronary stenting in patients with reduced left ventricular ejection fraction and mitral regurgitation of ischemic genesis. *I.P. Pavlov Russian Medical Biological Herald.* 2021;29(3):419–426. DOI: https://doi.org/10.17816/PAVLOVJ60221

Received: 07.02.2021 **Accepted:** 06.09.2021 **Published:** 30.09.2021

INTRODUCTION

The problem of ischemic mitral insufficiency (MIn) remains relevant up to the present time [1, 2]. Dilatation of the left ventricle (LV) leads to distension of the mitral valve ring, which, in turn, leads to mitral regurgitation (MR) of a different extent and severity. The most common cause of ischemic dilatation of the LV is long-standing atherosclerosis of the coronary arteries (CA) [1–3]. If the pathology was not timely diagnosed, patients were admitted to the clinic with a triad: a reduction in the ejection fraction (EF) of the LV, Min, and multivascular lesions of CA. The gold standard for treating such patients is coronary artery bypass surgery with prosthetics/plasty of the mitral valve [4, 5].

Without special preparation, however, these patients demonstrate a high percentage of lethal outcomes (in some cases, patients are refused surgical treatment and/or offered a heart transplantation operation) [4, 6]. This is directly associated with myocardial hibernation, inadequate myocardial perfusion with custodial during the operation, a prolonged switch-off of the artificial blood-circulation apparatus due to pronounced heart weakness, leading to high-dose adrenomimetic use [7]. For preoperative preparation of patients with such pathology, intra-aortic balloon counterpulsation (IABC) support is used. It has repeatedly been proven that IABC improves myocardial perfusion and increases EF LV [7, 8]. However, in several patients, the MIn dynamics were such that the surgical treatment volume and the surgical revascularization method were changed because of the need for MR correction [1, 6, 9, 10].

Aim — this study analyzes the dynamics of ischemic mitral regurgitation and clinical outcomes in patients with reduced left ventricular ejection fractions and multivascular lesions of the coronary arteries using intra-aortic balloon counterpulsation in coronary bypass surgery and coronary stenting.

MATERIALS AND METHODS

A retrospective analysis of 186 patients with moderate or pronounced MR was conducted from 2010 to 2020. In all patients, coronary bypass surgery or stenting was performed in the cardiovascular surgery department of Donetsk Clinical Territorial Medical Association. Patients over 18 years old (average, 53.6 ± 6.32 years) were enrolled. All patients were divided into two groups based on the treatment method used.

Group 1 included 132 patients (91 men and 41 women) whose revascularization procedure was c*oronary artery bypass surgery*. The average LVEF was 34.1 ± 4.6% (minimal 26%, maximal 42%). In 89 patients, III degree MR was recorded before IABC support, 27 patients — II degree MR, and 16 patients — I degree MR (Table 1, Fig. 1A).

Group 2 included 54 patients (26 men and 28 women) who underwent *coronary artery stenting* as the revascularization method. This group included the patients with the most severe conditions (LVEF less than 25% and III degree MR, Table 1), associated with high surgical risks when performing traditional bypass surgery.

Table 1. The severity of Mitral Insufficiency in Study Groups before Intra-Aortic Balloon Counterpulsation Support

Study Group		n (%)	Vena contracta	
			Data Format	Result, mm
Group 1	I degree Mitral Insufficiency	16 (8.6%)	M ± σ Me [Q1–Q3]	2.1 ± 0.22 2.2 [1.9–2.4]
	II degree Mitral Insufficiency	27 (14.5%)	M ± σ Me [Q1–Q3]	4.9 ± 0.31 5.06 [4.6–5.2]
	III degree Mitral Insufficiency (left ventricle ejection fraction ≥26%)	89 (47.9%)	M ± σ Me [Q1–Q3]	6.2 ± 0.3.9 6.25 [5.9–6.8]
Group 2	III degree Mitral Insufficiency (left ventricle ejection fraction ≤25%)	54 (29.0%)	M ± σ Me [Q1–Q3]	6.3 ± 0.22 6.42 [5.8–7.0]

IABC was inserted in all 186 patients three days before the surgical intervention because of reduced LVEF (from 17% to 42%). IABC was used in 1:1 mode. Adrenomimetics were used in 19 patients because of

pronounced arterial hypotension. Also, 89 patients had signs of cardiac insufficiency (IIB stage). No patient was required to have surgical correction of MIn performed because the echocardiography (EchoCG) data showed no anatomic lesions of the cusps and other mitral valve structures. All patients had significant atherosclerotic lesions of the carotid arteries and arteries of the lower limbs (to the extent of occlusion). Also, 63% of patients had comorbid type 2 diabetes mellitus.

The duration (M ± σ) of the surgical intervention in group 1 was 245 ± 3 2 min, artificial circulation — 98 ± 14 min, of compression of the aorta — 56 ± 9 min, and stay in the hospital — 12 ± 2 days. In all the patients in whom the vena contracta (v.c.) in EchoCG before the surgery was more than 4.0 mm, intraoperative water testing was performed to identify the degree of MIn (Figure 2). IABC was switched off on the second day after the surgical intervention.

In group 2, the intervention duration (M ± σ) was 138 ± 19 min. In two patients, revascularization of five CA was performed (the trunk of the left coronary artery, the anterior descending artery, circumflex artery, obtuse marginal branch, right coronary artery), in 19 patients — four vessels (the anterior descending artery, circumflex artery, obtuse marginal branch, right coronary artery), in 27 patients — three vessels (anterior descending artery, circumflex artery, right coronary artery), in six patients — two vessels (anterior descending artery, circumflex artery). IABC was removed on average on the seventh day after revascularization.

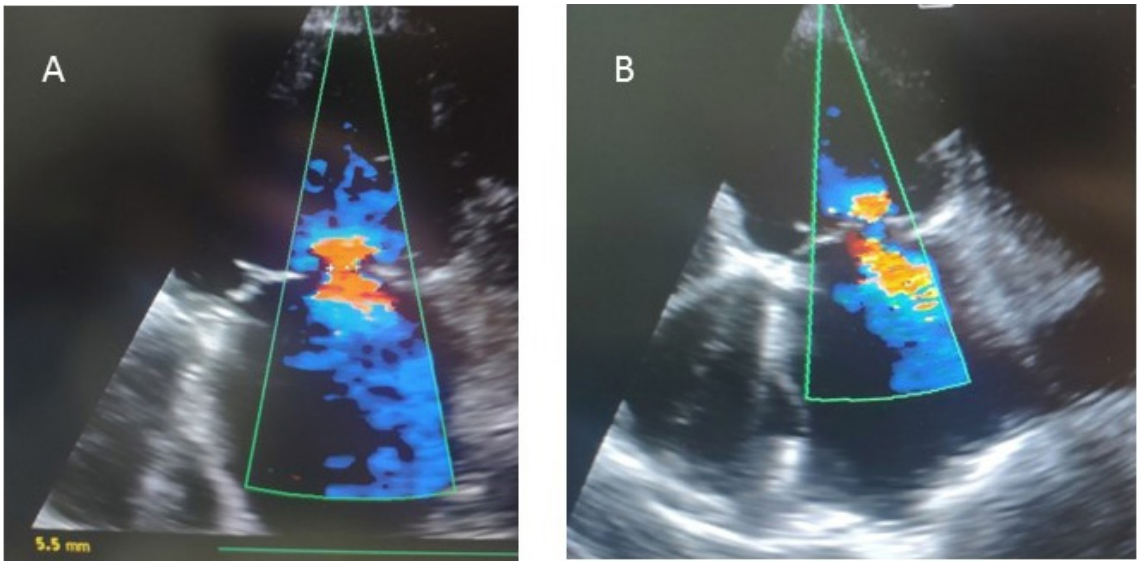

Fig. 1. Visualization of Mitral Insufficiency using color Doppler imaging before the surgical intervention: A — before insertion of Intra-Aortic Balloon Counterpulsation; B — with the working Intra-Aortic Balloon Counterpulsation in the early postoperative period.

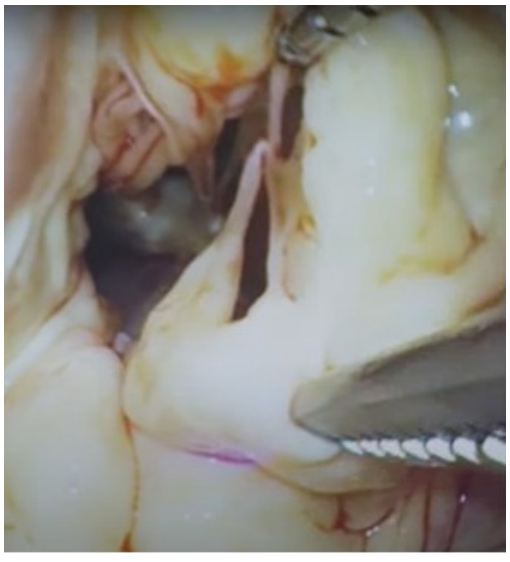

Fig. 2. Intraoperative revision of the mitral valve by conducting water testing.

DOI: https://doi.org/10.17816/PAVLOVJ60221

The results obtained were processed using Statistica 10.0 program (Stat Soft Inc., USA). The data are presented in the form of the mean (M), standard deviation (σ), median (Me), and interquartile range [Q1–Q3]. The statistical significance of the differences between the groups was assessed using the nonparametric Mann–Whitney test. The differences were considered statistically significant at $p < 0.05$.

RESULTS

The dynamics of v.c. and LVEF in the study groups during the follow-up period are given in Tables 2 and 3.

Table 2. Dynamics of *Vena contracta* and Left Ventricle Ejection Fraction in Study Groups in Hospital stage

Parameters	Data Format and *p*	Before Intra-Aortic Balloon Counterpulsation	3 Days of Intra-Aortic Balloon Counterpulsation	One hour after Surgery	7 Days after Surgery
Group 1					
Vena contracta, мм	M ± σ Me [Q1–Q3] *p*	5.7 ± 0.3 5.72 [1.9–6.8]	3.6 ± 0.4 3.74 [1.4–4.3] *0.005*	3.7 ± 0.3 3.84 [1.5–4.4] *0.005*	2.5 ± 0.7 2.74 [1.4–4.2] *0.005*
Left ventricle ejection fraction, %	M ± σ Me [Q1–Q3] *p*	34.1 ± 4.6 36.1 [26.2–42.0]	42 ± 2.4 45.6 [31.8–50.4] *0.0003*	41 ± 2.7 44.2 [30.7–48.9] *0.0003*	44 ± 1.9 45.6 [32.1–50.3] *0.0003*
Group 2					
Vena contracta, мм	M ± σ Me [Q1–Q3] *p*	6.3 ± 0.3 6.52 [6.1–7.2]	2.1 ± 0.5 2.24 [2.0–3.2] *0.001*	2.2 ± 0.3 2.12 [1.8–3.3] *0.001*	2.2 ± 0.5 2.21 [1.8–3.9] *0.001*
Left ventricle ejection fraction, %	M ± σ Me [Q1–Q3] *p*	20.3 ± 2.1 21.4 [17.1–24.9]	37 ± 2.9 38.3 [27.4–43.1] *0.0003*	37 ± 2.8 38.6 [26.9–42.5] *0.0003*	41 ± 2.8 42.5 [29.4–46.1] *0.0003*

Note: p — reflects statistically significant difference compared with the given parameter before insertion of Intra-Aortic Balloon Counterpulsation

Table 3. Dynamics of *Vena contracta* and Left Ventricle Ejection Fraction in Study Groups at 6 and 12 Months of Observation

Parameters	Data Format and *p*	6 Months	12 Months
Group 1			
Vena contracta, мм	M ± σ Me [Q1–Q3] *p*	2.6 ± 0.3 2.72 [1.5–4.1] *0.005*	2.7 ± 0.5 2.83 [1.5–4.2] *0.005*
Left ventricle ejection fraction, %	M ± σ Me [Q1–Q3] *p*	43 ± 3.2 45.2 [31.1–48.7] *0.005*	42 ± 2.7 44.6 [30.9–49.4] *0.005*
Group 2			
Vena contracta, мм	M ± σ Me [Q1–Q3] *p*	2.2 ± 0.4 2.26 [1.7–4.1] *0.001*	–
Left ventricle ejection fraction, %	M ± σ Me [Q1–Q3] *p*	39.3 ± 1.4 40.7 [29.3–45.8] *0.0003*	–

Note: p — reflects statistically significant difference compared with the given parameter before insertion of Intra-Aortic Balloon Counterpulsation

In ***group 1*** with the application of IABC, a statistically significant reduction in the degree of MIn (based on the change in the diameter of the v.c.) by 58% ($p < 0.05$) in the early postoperative period (Fig. 1B) and by 54% ($p < 0.05$) more than six months after the surgical intervention. This parameter remained at this level for a long observation period, with a minimum of 12 months.

Complications: Massive postoperative bleeding (required resternotomy) occurred in three patients, whereas 26 patients had paroxysmal forms of rhythm disorder in the postoperative period (was eliminated conservatively). Two patients required the implantation of electrocardiostimulators in the postoperative period because they developed complete atrioventricular blocks. Also, four patients died in the early postoperative period (three due to acute mesenteric ischemia and one — ischemic stroke).

In ***group 2***, with the application of IABC, a statistically significant reduction in the degree of MIn (based on changes in the diameter of the v.c.) by 42% ($p < 0.05$) in the early postoperative period and by 41% ($p < 0.05$) at more than six months after surgical treatment. There was also a statistically significant increase in LVEF by 78% ($p < 0.05$) seven days after surgery and by 84% ($p < 0.05$) six months after surgical treatment.

In the second group, no deaths occurred. In nine patients, negative dynamics were noted on the ECG in the first five days (negative T wave in V4–V6 leads), which is most probably associated with intraoperative damage to the myocardium resulting from temporary vessel closure during stenting.

DISCUSSION

Our data agree with those of other authors. According to a meta-analysis of seven randomized and 16 observational studies, including 9212 patients, the preventive use of IABC reduced the risk of lethality in randomized clinical studies by 4.4% (odds ratio 0.43; 95% confidence interval 0.25–0.73; $p = 0.0025$). Besides, the patient length of stay with preoperative IABC support in an intensive care unit ($p < 0.0001$) and in a hospital ($p < 0.0001$) also significantly decreased. According to the analysis, current randomized clinical trial and observational study data enable patients at high risk before coronary aortic bypass surgery to expect favorable effects of IABC [11]. Similar data are provided in the review by Poirier et al. [12].

CONCLUSION

Thus, intra-aortic balloon counterpulsation in patients with a low left ventricular ejection fraction, moderate and pronounced mitral insufficiency, and significant pathology of the coronary arteries permitted a reduction in the duration of surgical treatment and artificial circulation (in study group 1) by refusing surgical correction of mitral insufficiency. In group 2, it permitted the complete refusal of additional intervention (for valve prosthesis or plasty) because of the absence of these indications (the average time of correction of isolated mitral regurgitation by valve plasty/prosthetics is 15–25 min). Besides, these patients do not need to take anticoagulants, which reduce the risk of developing early and late hemorrhagic complications.

It is also possible to use intra-aortic balloon counterpulsation to treat patients in extremely severe conditions (those inoperable with traditional methods due to high risks). It is not only the volume of surgical intervention that changes, but also the method of revascularization changes to a minimally invasive one. This almost always reduces the risks of surgical treatment for a patient.

ADDITIONAL INFORMATION

Funding. Budget of Gorky Donetsk National Medical University.

Conflict of interest. The authors declare no conflict of interests.

Patient consent. The study used data from people in accordance with signed informed consent.

Contribution of the authors: *Yu. D. Kostyamin* — concept of the study, collection and processing of the material, writing the text, *V. Yu. Mikhaylichenko, N. K. Baziyan–Kukhto, I. S. Grekov* — collection and processing of the material, writing the text.

Финансирование. Бюджет Донецкого национального медицинского университета им. М. Горького.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

Согласие на публикацию. В исследовании использованы данные людей в соответствии с подписанным информированным согласием.

Вклад авторов: *Костямин Ю.Д.* — концепция статьи, сбор и обработка материала, написание текста, *Михайличенко В.Ю., Базиян–Кухто Н.К., Греков И.С.* — сбор и обработка материала, написание текста.

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