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Предикторы отдаленных осложнений бедренно-подколенного шунтирования аутовенозным трансплантатом

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АННОТАЦИЯ

Введение. Атеросклеротическое поражение артерий нижних конечностей зачастую сопровождается развитием хронической, а далее — критической ишемии нижних конечностей. Вопросы реваскуляризации в этих условиях всегда стояли в центре внимания сосудистых хирургов всего мира.

Цель. Анализ предикторов отдаленных осложнений после бедренно-подколенного шунтирования (БПШ) аутовенозным трансплантатом.

Материалы и методы. В настоящее ретроспективное, открытое исследование за период с 10.01.2016 по 25.12.2019, проведенное в Научно-исследовательском институте — Краевой клинической больнице №1 имени профессора С. В. Очаповского (г. Краснодар), было включено 464 пациента, которым выполнялось БПШ венозным аутотрансплантатом. Применялись следующие разновидности аутовенозных кондуитов: n = 266 — реверсированная вена (большая подкожная вена (БПВ)); n = 59 — аутовена (БПВ), подготовленная in situ; n = 66 — аутовена (БПВ), подготовленная ex situ; n = 73 — вены верхней конечности. Отдаленный период наблюдения составил 16,6 ± 10,3 мес.

Результаты. В госпитальном послеоперационном периоде летальный исход и инфаркт миокарда наблюдались в единичных случаях. Ишемические инсульты не диагностировались. У 4,5% пациентов развился тромбоз шунта, 2,1% — потребовалась ампутация конечности. Ревизия послеоперационной раны по поводу кровотечения осуществлялась в 1,7% случаев. В отдаленном периоде наблюдения неблагоприятные кардиоваскулярные события отмечались у каждого пятого больного (21,8%). Тромбоз шунта был диагностирован в 17,4% случаев, в 5,1% — выполнена ампутация конечности. Для идентификации факторов неблагоприятного прогноза вся выборка была разделена на две группы: 1 группа (n = 366) — без отдаленных осложнений; 2 группа (n = 99) — с отдаленными осложнениями. При помощи расчета отношения шансов (ОШ) выявлены следующие предикторы неблагоприятных кардиоваскулярных событий: ожирение I степени (p < 0,0001; ОШ = 3,24; 95% доверительный интервал (ДИ) = 1,93–5,43), ожирение II степени (p = 0,0005; ОШ = 4,84; 95% ДИ = 1,71–13,67), хроническая ишемия нижних конечностей (ХИНК) IIБ стадии (p = 0,0006; ОШ = 2,24; 95% ДИ = 1,42–3,52). Протективными факторами стали постинфарктный кардиосклероз (p = 0,04; ОШ = 0,51; 95% ДИ = 0,27–0,95), избыточная масса тела (p = 0,01; ОШ = 0,56; 95% ДИ = 0,35–0,88), ХИНК IV стадии (p = 0,01; ОШ = 0,53; 95% ДИ = 0,32–0,86).

Выводы. БПШ венозным аутотрансплантатом характеризуется низкой частотой осложнений в госпитальном и отдаленном периодах наблюдения, что делает данную операцию методом выбора открытого хирургического лечения больных с протяженным атеросклеротическим поражением поверхностной бедренной артерии. Предикторами неблагоприятных кардиоваскулярных событий в отдаленном периоде наблюдения являются ожирение I степени, ожирение II степени, ХИНК IIБ стадии. Протективными факторами развития отдаленных послеоперационных осложнений стали постинфарктный кардиосклероз, избыточная масса тела, ХИНК IV стадии. Представленные результаты необходимо учитывать при создании шкал стратификации риска неблагоприятных кардиоваскулярных событий у пациентов после БПШ. Прецизионная курация пациентов с выявленными предикторами осложнений позволит снизить риски развития данных состояний, увеличив отдаленную выживаемость, свободную от тромбоза шунта и ампутации конечности.

Ключевые слова: *бедренно-подколенное шунтирование; большая подкожная вена; аутовенозный трансплантат; венозный аутотрансплантат; аутовена ex situ; аутовена in situ; предикторы осложнений*

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Predictors of Long-Term Complications of Femoropopliteal Bypass with Autovenous Graft

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ABSTRACT

INTRODUCTION: Atherosclerotic lesion of lower limb arteries often occurs with the development of chronic and later with critical ischemia of the lower limbs. Revascularization in these conditions has always been at the center of attention of vascular surgeons worldwide.

AIM: To analyze long-term complications after femoropopliteal bypass (FPB) with the autovenous graft.

MATERIALS AND METHODS: This retrospective open study was conducted in Scientific the Research Institute — Regional Clinical Hospital No. 1 named after Professor S. V. Ochapovsky (Krasnodar) in the period from January 10, 2016, to December 25, 2019, and included 464 patients who underwent FPB with venous autograft. The following autovenous conduits were used: n = 266, reverse vein (great saphenous vein (GSV)); n = 59, autovein (GSV) prepared in situ; n = 66, autovein (GSV) prepared ex situ; and n = 73, veins of an upper limb. The long-term follow-up period was 16.6 ± 10.3 months.

RESULTS: During the postoperative hospital period, single cases of lethal outcome and myocardial infarction were noted. No ischemic strokes were recorded. Shunt thrombosis developed in 4.5% of the patients, and 2.1% required limb amputation. Postoperative wound revision caused by bleeding was performed in 1.7% of the cases. In the remote follow-up period, adverse cardiovascular events were noted in every fifth patient (21.8%). Shunt thrombosis was diagnosed in 17.4% of cases, and limb amputation was performed in 5.1% of the cases. To identify the factors for poor prognosis, the whole sample was divided to two groups: group 1 (n = 366) included those without long-term complications and group 2 (n = 99) comprised patients with long-term complications. Using the odds ratio (OR), the following predictors of adverse cardiovascular events were identified: degree I obesity ($p < 0.0001$; OR = 3.24; 95% confidence interval (CI) = 1.93–5.43), degree II obesity ($p = 0.0005$; OR = 4.84; 95% CI = 1.71–13.67), and stage IIB chronic lower limb ischemia (CLLI) ($p = 0.0006$; OR = 2.24; 95% CI = 1.42–3.52). Protective factors were postinfarction cardiosclerosis ($p = 0.04$; OR = 0.51; 95% CI = 0.27–0.95), excessive body mass ($p = 0.01$; OR = 0.56; 95% CI = 0.35–0.88), and stage IV CLLI ($p = 0.01$; OR = 0.53; 95% CI = 0.32–0.86).

CONCLUSIONS: FPB with venous autograft is characterized by a low frequency of complications in the hospital and long-term follow-up periods, making this technique a method of choice for the open surgical treatment of patients with extended atherosclerotic lesion of the superficial femoral artery. Predictors of adverse cardiovascular events in the long-term period are degree I obesity, degree II obesity, and stage IIB CLLI. Protective factors against the development of long-term surgical complications are postinfarction cardiosclerosis, overweight, and stage IV CLLI. The presented results should be considered when constructing stratification risk scales for adverse cardiovascular events in patients who underwent FPB. Precision management of patients with identified predictors of complications will allow the reduction of the risks for the development of these conditions and increase long-term survival free from shunt thrombosis and limb amputation.

Keywords: *femoropopliteal bypass; great saphenous vein; autovenous graft; venous autograft; autovein in situ; autovein ex situ; predictors of complications*

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ECO•VECTOR

LIST OF ABBREVIATIONS

GSV — great saphenous vein
FPB — femoropopliteal bypass
DFA — deep femoral artery
CI — confidence interval
MI — myocardial infarction
ACVA — acute cerebrovascular accident
OR — odd ratio
SFA — superficial femoral artery
PICS — postinfarction cardiosclerosis
CLLI — chronic lower limb ischemia
BARC —Bleeding Academic Research Consortium
TASC II — Trans-Atlantic Inter-Society Consensus II

INTRODUCTION

Femoropopliteal bypass (FPB) is a variant of revascularization of the lower limb which has proven its effectiveness and safety in case of extended atherosclerotic lesion [1–3]. According to the literature, the quality of reconstruction directly depends on a number of factors one of which is selection of the type of bypass [4–6].

A classic variant of the most optimal kind of conduit for FPB is a venous autograft [1–3]. As the latter, the great saphenous vein (GSV) or veins of the upper limbs are most often used [1–3, 7, 8]. Both of them demonstrated higher patency at all stages of the postoperative period relative to artificial analogs [7–10]. Synthetic and biological prostheses can be used in the absence of a suitable GSV [11–14]. Both variants are characterized by a high risk of development of restenoses and infectious complications throughout all follow-up periods [11–14]. With this, according to the literature, biological prostheses are subject to aneurysmal deformation associated with increased probability for distal embolism and thrombosis [11, 12, 15, 16]. The way out of the situation is introduction of the external metal braid at the factory stage of production, that prevents pathological dilatation [17]. However, this manufacturing process is very expensive in comparison with the existing artificial analogs, which limits routine application of this prosthesis [17]. Therefore, today the "first line" conduit for FPB is GSV [1–3].

Despite the mentioned facts, the use of an autovenous graft does not exclude the risk of restenosis and thrombosis after FPB either [1–3, 7, 8]. At present, there is a deficit of studies devoted to predictors of development of complications after the open revascularization of the lower limb. Here, the timely identification of factors of poor prognosis could identify the patients who are under a higher risk of development of the above events. Precise management and prophylaxis could permit to reduce the rate of shunt dysfunction and loss of limbs in this cohort of patients.

This study **aimed** to analysis of predictors of long-term complications after femoropopliteal bypass with autovenous transplant.

MATERIALS AND METHODS

The work was carried out in compliance with the standards of Good Clinical Practice and principles of Declaration of Helsinki, and did not contradict the Federal Law of the Russian Federation of 2011, 21 November No. 323-FL "On fundamental healthcare principles in the Russian Federation" and the order of Ministry of Health of Russian Federation of 2016, April 1 № 200n "On approval of regulations of good clinical practice". Due to the fact that no additional interventions were performed and the study was of retrospective character, no approval of the Ethical Committee was required, patients signed informed consent on the basis of standard procedures of the medical institution at the time of hospitalization.

The retrospective open study for the period from 2016, 10 January to 2019, 25 December conducted in the Scientific Research Institute — prof. Ochapovsky Regional Clinical Hospital No.1 (Krasnodar) involved 464 patients who underwent FPB with venous autograft. In all cases, based on multispiral computed tomography with angiography, an extended (25 cm or more) atherosclerotic occlusive lesion of the superficial femoral artery was detected (PBA), corresponding to type D according to the Transatlantic Consensus (TASC II) [1–3]. The degree of chronic lower limb ischemia (CLLI) was determined according to Fontaine–Pokrovsky classification.

The method of revascularization and kind of shunt were selected by multidisciplinary consultation including vascular surgeon, endovascular surgeon, cardiologist, resuscitator, anesthesiologist.

The following kinds of autovenous conduits were used:

- reverse vein (n = 266, GSV);
- autovein (GSV), prepared *in situ* (n = 59);
- autovein (GSV), prepared *ex situ* (n = 66);
- upper limb veins (n = 73).

The method of ex situ preparation of GSV was developed on the base of Scientific and Research Institute — prof. Ochapovsky Regional Clinical Hospital No. 1 (Patent "Method of preparation of great saphenous vein for femoropopliteal bypass", application for invention No. 2021137226 of 2021, 16 December). The method was implemented in the following way: GSV of the required length was isolated from the sapheno-femoral junction

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in distal direction and taken out from the wound, then valvulotomy was performed through the proximal end of GSB. A valvulotome was removed, and a metal cannula was inserted, through which the room temperature saline solution with unfractionated heparin was introduced into the lumen of GSV with a syringe to imitate the blood flow, and the quality of the conducted valvulotomy was checked. The technical result of a new kind of FPB was achieved due to use of the proposed method of preparation of autovenous bypass in which, after the isolation of GSV, the described valvulotomy was conducted ex situ with the subsequent drawing of the shunt without reversion subfascially orthtopically along the route of the neurovascular bundle by tunneling (tunneler Sheath Tunneler Set; Peripheral Vascular, USA) of soft tissues.

Inclusion criteria:

1) existence of extended atherosclerotic occlusive lesion of SFA (25 cm and more);

2) absence of decompensate comorbid pathology (diabetes mellitus, chronic heart failure, etc.);

3) implementation of FPB with autovenous graft.

Non-inclusion criteria:

1) existence of pathology limiting observation of the patient in the long-term period;

2) absence of autovein suitable for FPB.

In the hospital and long-term (16.6 ± 10.3 months) follow-up periods, the following ***kinds of complications*** were considered:

1) lethal outcome;

2) shunt thrombosis;

3) bleeding of 3b and higher type (requiring wound revision) on Bleeding Academic Research Consortium (BARC) scale;

4) postoperative wound infection;

5) limb amputation;

6) myocardial infarction (MI);

7) acute cerebrovascular accident (ACVA);

8) combined endpoint (the sum of the above complications).

Most patients were of male gender, of elderly age and had a chronic obstructive pulmonary disease. Every third patient had diabetes mellitus and overweight, every fifth patient had I-II functional class angina (Table 1).

In half of all cases, IIB stage chronic lower limb ischemia (CLLI) according to Fontaine–Pokrovsky classification was observed (Table 2).

To identify the factors of poor prognosis, the sample was divided to two groups:

group 1 (n = 366) — without long-term complications;

group 2 (n = 99) — with long-term complications

The results of the study were processed using the Graph Pad Prism application software package (www.graphpad.com). The groups were compared using χ^2 Pearson criterion. The differences were considered statistically significant at $p < 0.05$. The relative risk of development of adverse cardiovascular events was calculated and presented as odd ratio (OR) with indication of 95% confidence interval (CI).

Table 1. Clinical and Demographic Characteristics of Patients

Parameter	n	%
Age under 44 years	12	2.6
Age 45–59 years	126	27.1
Age 60–74 years	290	62.5
Age above 75 years	36	7.75
Male gender	417	89.9
Diabetes mellitus	159	34.3
Insulin-dependent diabetes mellitus	57	12.3
Chronic obstructive pulmonary disease	374	80.6
Chronic kidney disease	17	3.7
Acute cerebrovascular accident in history	39	8.4
Postinfarction cardiosclerosis	52	11.2
I–II functional class angina pectoris	102	22.0
Overweight	149	32.1
I degree obesity	198	42.7
II degree obesity	66	14.2
II functional class chronic heart failure	439	94.6
Multifocal atherosclerosis (subclinical) involving three arterial systems	17	3.7

Table 2. Severity of Chronic Lower Limb Ischemia According to Fontaine–Pokrovsky Classification

Stage of Chronic Lower Limb Ischemia	n	%
IIB stage	256	55.2
III stage	96	20.7
IV stage	110	23.7

RESULTS

In hospital postoperative period, the lethal outcome, MI were diagnosed in single cases. ACVA were not diagnosed. In 4.5% of patients, shunt thrombosis developed, in 2.1% of cases limb amputation was required. Revision of postoperative wound for bleeding was performed in 1.7% of cases (Table 3). In the long-term follow-up period, adverse cardiovascular events were noted in every fifth patient (21.8%). The diagnosis of shunt thrombosis was made in 17.4% of cases, in 5.1% of cases limb amputation was performed (Table 3).

Table 3. Hospital and Long-Term Complications in Patients after Femoropopliteal Bypass

Parameter	Hospital Period	Long-Term Period
Lethal outcome, n (%)	1 (0.2)	18 (4.0)
Myocardial infarction, n (%)	1 (0.2)	6 (1.3)
Acute cerebrovascular accident, n (%)	0	4 (0.9)
Shunt thrombosis, n (%)	21 (4.5)	79 (17.4)
Bleeding of 3b and higher type on BARC scale	8 (1.7)	0
Infection of postoperative wound, n (%)	6 (1.3)	0
Limb amputation, n (%)	10 (2.1)	23 (5.1)
Combined endpoint, n (%)	0	99 (21.8)

Note: BARC — Bleeding Academic Research Consortium

On the basis of OR calculation, predictors of adverse cardiovascular events and protective factors were identified (Table 4).

Thus, the ***following predictors of adverse cardiovascular events*** were identified:

- I degree obesity ($p < 0.0001$; OR = 3.24; 95% CI = 1.93–5.43);
- II degree obesity ($p = 0.0005$; OR = 4.84; 95% CI = 1.71–13.67);
- IIB stage CLLI ($p = 0.0006$; OR = 2.24; 95% CI = 1.42–3.52).

The following factors produced ***protective influence***:

- postinfarction cardiosclerosis (PICS) ($p = 0.04$; OR = 0.51; 95% CI = 0.27–0.95);
- overweight ($p = 0.01$; OR = 0.56; 95% CI = 0.35–0.88);
- IV stage CLLI ($p = 0.01$; OR = 0.53; 95% CI = 0.32–0.86).

DISCUSSION

Complication rate of hospital and long-term periods obtained in this study, agrees with the world data [1–4, 6]. FPB with the autovein demonstrates high safety and effectiveness confirmed by duration of functioning of the conduit and the minimal rate of adverse cardiovascular events. Nevertheless, isolation of risk factors and identification of a subgroup of patients possessing these characteristics, could reduce the likelihood of remote complications through precise observation and careful management of this group of patients.

In the Russian literature, according to the data of electronic library www.elibrary.ru, there is a deficit of studies devoted to identification of risk factors for adverse cardiovascular events after femoropopliteal bypass. V. F. Khlebov (2002) in his study paid special attention to the deep femoral artery (DFA) [18]. According to the author's conclusion, with the diameter of DFA less than 3.5 mm and blood flow velocity less than 0.3 m/sec, the risk of early shunt thrombosis increases [18]. Nevertheless, the mathematical equations for determination of the probability for this complication, presented in this study, appeared too bulky for use in the routine practice.

Table 4. Identified Predictors of Long-Term Complications

Parameter	Group 1 (without complications)	Group 2 (with complications)	p	OR	95% CI
n	366	99	–	–	–
Age under 44 years, n (%)	10 (2,7)	2 (2,0)	1,0	1,36	0,30–6,07
Age 45–59 years, n (%)	99 (27,0)	27 (27,3)	1,0	0,98	0,60–1,62
Age 60–74 years, n (%)	229 (62,7)	61 (61,6)	0,81	1,05	0,66–1,66
Age above 75 years, n (%)	27 (7,4)	9 (9,1)	0,53	0,79	0,36–1,75
Male gender, n (%)	325 (88,8)	92 (92,9)	0,26	0,60	0,26–1,38
Diabetes mellitus, n (%)	122 (33,3)	37 (37,4)	0,47	0,83	0,52–1,32
Insulin-dependent diabetes mellitus, n (%)	42 (11,5)	15 (15,1)	0,30	0,72	0,38–1,37
Chronic obstructive pulmonary disease, n (%)	289 (78,9)	85 (85,8)	0,15	0,61	0,33–1,14
Chronic kidney disease, n (%)	12 (3,3)	5 (5,0)	0,37	0,63	0,21–1,85
Acute cerebrovascular accident in history, n (%)	32 (8,7)	7 (7,1)	0,68	1,25	0,53–2,94
Postinfarction cardiosclerosis, n (%)	35 (9,5)	17 (17,2)	***0,04***	***0,51***	***0,27–0,95***
I–II Functional class angina pectoris, n (%)	79 (21,6)	23 (23,2)	0,78	0,90	0,53–1,54
Overweight, n (%)	107 (29,2)	42 (42,4)	***0,01***	***0,56***	***0,35–0,88***
I Degree obesity, n (%)	176 (48,1)	22 (22,2)	***< 0,0001***	***3,24***	***1,93–5,43***
II Degree obesity, n (%)	62 (16,9)	4 (4,0)	***0,0005***	***4,84***	***1,71–3,67***
II Functional class chronic heart failure	345 (94,3)	94 (94,9)	1,0	0,87	0,32–2,38
Multifocal atherosclerosis (subclinical) with involvement of three arterial systems	13 (3,5)	4 (4,0)	0,76	0,87	0,27–2,74
IIB Stage chronic lower limb ischemia	217 (59,3)	39 (39,4)	***0,0006***	***2,24***	***1,42–3,52***
III Stage chronic lower limb ischemia	69 (18,8)	27 (27,3)	0,07	0,61	0,37–1,03
IV Stage chronic lower limb ischemia	77 (21,0)	33 (33,3)	***0,01***	***0,53***	***0,32–0,86***
Femoropopliteal bypass with autovein *in situ* above the knee joint cleft	28 (7,6)	7 (7,1)	1,0	1,08	0,46–2,57
Femoropopliteal bypass with autovein *in situ* below the knee joint cleft	18 (4,9)	5 (5,0)	1,0	0,97	0,35–2,68
Femoropopliteal bypass with reverse autovein above the knee joint cleft	153 (41,8)	33 (33,3)	0,13	1,43	0,92–1,69
Femoropopliteal bypass with reverse autovein below the knee joint cleft	60 (16,4)	23 (23,2)	0,13	0,64	0,37–1,11
Femoropopliteal bypass with autovein *ex situ* above the knee joint cleft	32 (8,7)	5 (5,0)	0,29	1,80	0,68–4,75
Femoropopliteal bypass with autovein *ex situ* below the knee joint cleft	18 (4,9)	10 (10,1)	0,09	0,46	0,20–1,03
Femoropopliteal bypass with upper limb autovein above the knee joint cleft	40 (10,9)	10 (10,1)	1,0	1,09	0,52–2,27
Femoropopliteal bypass with upper limb autovein below the knee joint cleft	17 (4,6)	6 (6,1)	0,60	0,75	0,28–1,96
Thrombectomy from shunt in hospital period with no subsequent amputation	14 (3,8)	8 (8,1)	0,1	0,45	0,18–1,11
Bleeding of 3b and higher type on BARC scale in hospital period	6 (1,6)	2 (2,0)	0,68	0,80	0,16–4,07
Infection of postoperative wound in hospital period	6 (1,6)	2 (2,0)	0,68	0,80	0,16–4,07

Notes: OR — odd ratio, CI — confidence interval; BARC — Bleeding Academic Research Consortium

N. N. Burkov, et al. (2013) published the results of the study which determined the total contribution of metabolic and genetic factors to the risk of thrombosis and shunt restenosis [19]. The data obtained proved that the use of a mathematical model including these criteria, can reduce the frequency of the early thrombosis from 17% to 2% [19]. Along with this, both V. F. Khlebov and N. N. Burkov, et al. emphasized the need for reconstruction of the DFA as an important stage of the operation that can improve the postoperative prognosis for survival free from limb amputation [18, 19]. However, the limitation of these studies was that they rested on the results of FPB with a biological prosthesis, which did not allow taking into account the factors that were identified with use of autovenous transplants.

B. V. Kasyanov (2019) identified predictors of occlusion of femoropopliteal shunts in 136 patients [20]. According to the author, considerable degree of ischemia, occlusion of SFA and diabetes mellitus reduced the primary patency 0.44, 0.97 and 0.04 times, respectively. The author also stated that the duration of shunt functioning depends, among other things, on the patient's compliance. Adherence to the recommendations and the prescribed drug therapy reduced the likelihood of shunt dysfunction in the remote postoperative period [20].

In our study, I and II degree obesity was identified among the predictors of the development of long-term complications. On the one hand, this may emphasize the fact that patients do not follow the doctor's recommendations which practically always include normalization of the body weight. On the other hand, obesity often combines with such comorbid conditions as multifocal atherosclerosis, diabetes mellitus [21]. This pathology can be accompanied by dyslipidemia, macro- and microangiopathy [21–23]. It has been repeatedly shown that these conditions are associated with increased risk of restenosis and activation of the rapid progression of coronary and peripheral atherosclerosis [21–23]. The process ends in shunt dysfunction, the development of MI, ACVA and other adverse events [21–23]. Therefore, obesity may mask much more global pathological changes.

Another predictor of complications is IIB stage CLLI. On the other hand, IV stage CLLI is a protective factor. As a rule, a more severe degree of ischemia takes a much longer period to develop than IIB stage. The fourth stage runs with formation of trophic alterations, pain at rest, which forms a more responsible attitude to drug treatment in a patient [24]. Therefore, a positive result of revascularization that rids a patient of severe symptoms of IV stage CLLI, is of greater value for a patient than in the group with less pronounced lesion. In this connection, compliance of this cohort of patients will be significantly higher in comparison with representatives of IIB group, that will be reflected in reduction of the rate of long-term complications.

Among protective factors there are also overweight and PICS. In these cases, one should again speak about compliance. Most patients with overweight keeping to the diet, reduced the weight and left the group of obesity. Patients with a history of MI, having suffered such a serious cardiovascular event, demonstrate a more responsible approach to hypolipidemic and desaggregant therapy. Such approach produces a cross effect on the period of shunt functioning, preventing progression of atherosclerosis and restenosis [22, 23].

A particular attention should be given to a new FPB methodology developed in our center. The study showed that ex situ FPB with the autovein below the knee joint cleft did not achieve a statistically significant parameter, although it had such a tendency ($p = 0.09$; OR = 0.46; 95% CI = 0.20–1.03) with a protective mechanism of action. Probably, if the period of training of the personnel in the new surgical method had been excluded, the result could have achieved the required level of evidence. The advantages of this method of FPB include two components.

First, *valvulotomy* in FPB is performed outside the wound under control of vision, which excludes damage to the vessel wall with subsequent hemorrhagic phenomena.

Second, *orthotopical* position of the shunt creates maximally natural conditions for mechanical protection of the conduit. Thus, the subsequent increase in this sample will probably lead to statistically significant reduction of frequency of long-term complications after FPB with the autovein ex situ relative to other surgical methods. The use of this surgical method will become an important preventive factor in achieving the optimal outcome of the surgery.

CONCLUSIONS

1. Femoropopliteal bypass with venous autograft is characterized by low frequency of complications in hospital and long-term periods, which makes this surgery a method of choice of open surgical treatment of patients with extended atherosclerotic lesion of superficial femoral artery.

2. Predictors of adverse cardiovascular events in the long-term follow-up period are first and second degree obesity, IIB stage chronic ischemia of lower limbs.

3. Postinfarction cardiosclerosis, overweight, and IV stage chronic lower limb ischemia were registered as protective factors in terms of development of long-term postoperative complications.

4. It is reasonable to take the presented results into consideration in creation of scales of stratification or risk for adverse cardiovascular events in patients after femoropopliteal bypass surgery.

5. Precision management of patients with identified predictors of complications will permit to reduce the risks of development of the given conditions and increase the long-term survival free from shunt thrombosis and amputation of limb.

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