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CLINIC OF VASCULAR SURGERY**

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**DELAYED REVASCULARIZATION IN PATIENTS
WITH ACUTE ARTERIAL ISCHEMIA OF
THE EXTREMITIES**

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ABBREVIATIONS USED

a.	arteria
et al.	et alierte
fig.	figure
incl.	inclusive
min	minutes

1. INTRODUCTION

During the recent years, an uninterrupted advancing in age of the population and an increasing morbidity rate of the socially significant cardiovascular diseases worldwide is observed. Acute arterial insufficiency of the extremities or acute ischemia of the extremities is a serious rapidly progressing arterial wall disease that immediately threatens patient's life and necessitates a timely and adequate treatment. Acute thrombosis, embolism and arterial injury are the main reasons. In spite of the advances of the rapid and precise diagnosis and the perfectioning of the complex treatment of the patients, the results do not completely meet the enhanced expectations and requirements of society.

Nowadays, various methods and their modifications for conservative and operative restoration of the arterial blood flow in the extremities are made use of. It deals with thrombolysis, anticoagulant, antithrombotic and endovascular therapy as well as with surgical revascularization, angioplastics, stenting, and bypass graft usage. Early revascularization is most effective, however, most patients are not hospitalized within an interval of several hours after the vascular accident only but several days after it. This imposes the use of the delayed revascularization with standard vascular accesses. We introduced in our practice the delayed revascularization with standard and distal vascular accesses and decided to juxtapose the results obtained with the application of the three revascularization methods.

The results from the systematic survey of the newly-published Bulgarian and foreign literature outline some non-clarified practical issues in terms of the possible optimization of the therapeutic behaviour in the patients with acute arterial ischemia of the extremities.

This gave us grounds to carry out the present investigation in order to identify in a comparative aspect the effectiveness and safety of the individualized application of the delayed revascularization with standard and distal vascular accesses in these patients.

2. PURPOSE AND TASKS

The purpose of the present dissertation work is to study in a comparative aspect our results from the application of the early and late revascularization in the patients with acute arterial ischemia of the extremities.

The tasks for accomplishment of this purpose are the following:

1. To analyze the diagnostic and prognostic value of the ankle-brachial index and wrist-ankle index in the patients acute arterial ischemia of the extremities.
2. To retrospectively analyze the results from the application of the early and delayed revascularization in the patients with thrombosis of the arteries of the extremities.
3. To retrospectively analyze the results from the application of the early and delayed revascularization in the patients with embolism of the arteries of the extremities.

4. To retrospectively analyze the results from the application of the early and delayed revascularization in the patients with injuries of the vessels of the extremities.

5. To outline the advantages of the delayed revascularization with standard and distal vascular accesses over the delayed revascularization with standard accesses in the patients acute arterial ischemia of the extremities admitted for treatment after the tenth hour from the onset of the disease.

6. To identify the frequency of the serious accompanying diseases in the patients acute arterial ischemia of the extremities.

3. MATERIAL AND METHODS

3.1. Material

We analyzed retrospectively the documentation of all the consecutive patients with acute ischemia of the extremities hospitalized in St. Panteleimon Hospital of Yambol during the period between January 1, 2011 and December 31, 2020 inclusive and having undergone early or late revascularization of the extremities.

It deals with a total of 273 patients at a mean age of $68,12 \pm 10,32$ years (range, 18 to 98 years). There are a total of 154 males at a mean age of $67,94 \pm 10,18$ years (range, 18 to 97 years) and a total of 119 females at a mean age of $74,03 \pm 11,41$ years (range, 21 to 98 years).

The annual dynamics of all the patients operated on can be seen in Fig. 1.

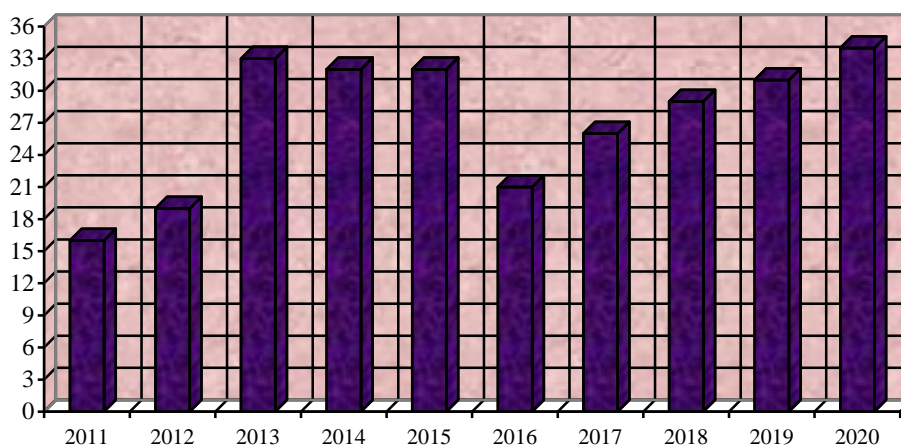


Fig. 1. Annual dynamics of all the patients operated on

We allocated the patients operated on with acute ischemia of the extremities into the following four groups - in consequence of thrombosis of one or several arteries, in consequence of embolism of one or several arteries, in consequence of injury of one or several arteries, and with imposed amputation of the extremity.

It dealt with a total of 102 patients with of thrombosis of the arteries of the extremities at a mean age of $69,15 \pm 8,12$ years, 60 males at a mean age of $67,38 \pm 7,63$ years and 42 females at a mean age of $72,21 \pm 9,41$ years.

The annual dynamics of all the patients operated on with thrombosis is illustrated in Fig. 2.

A total of 117 patients with embolism of the arteries of the extremities at a mean age of $72,71 \pm 9,11$ years, 61 males at a mean age of $69,31 \pm 7,43$ years and 56 females at a mean age of $76,91 \pm 8,04$ years were operated on.

The annual dynamics of all the patients operated on with embolism is shown in Fig. 3.

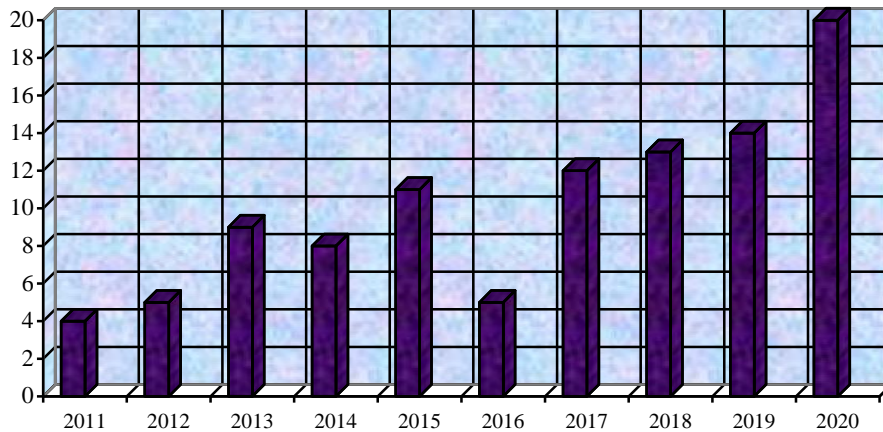


Fig. 2. Annual dynamics of all the patients operated on with thrombosis

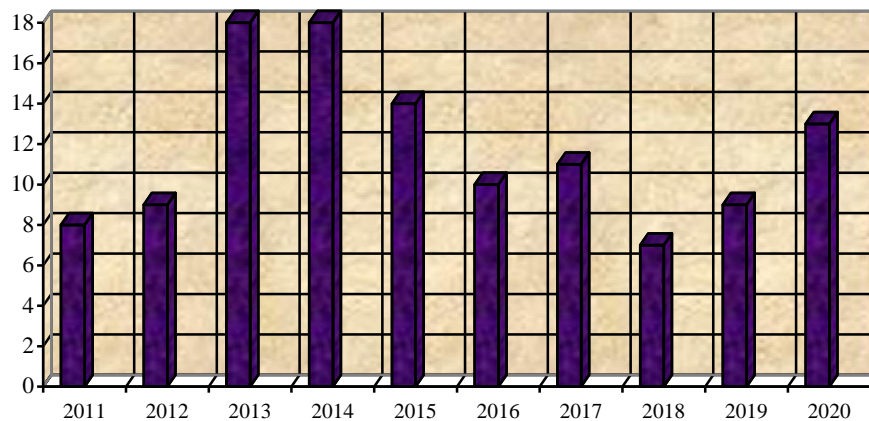


Fig. 3. Annual dynamics of all the patients operated on with embolism

During the period between 2012 and 2019, a total of 21 patients with injuries of the blood vessels, 20 males at a mean age of 42,92 years and one female aged 54 years were operated on. The annual dynamics of the males operated on is demonstrated in Fig. 4.

Amputation of the extremities because of thrombosis or embolism were performed during the period between 2011 and 2019 in a total of 33 patients at a mean age of $74,22 \pm 10,21$ years, 13 males at a mean age of $71,38 \pm 7,89$ years and 20 females at a mean age of $76,84 \pm 8,78$ years. The annual dynamics of all the patients with amputations of the extremities can be seen in Fig.5.

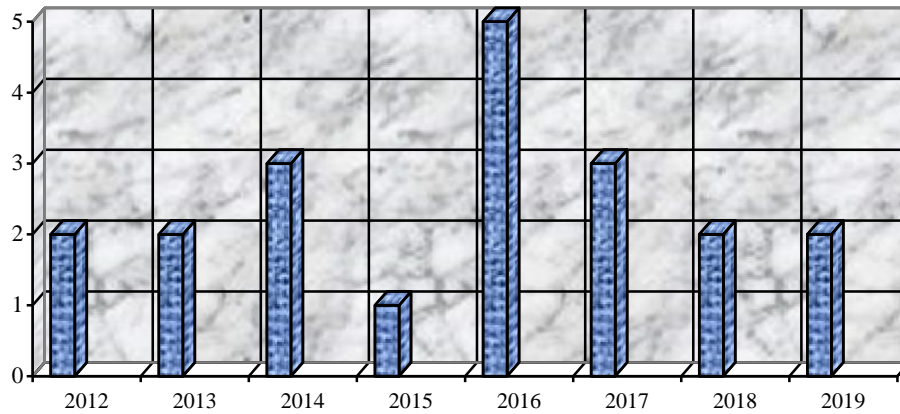


Fig. 4. Annual dynamics of all the males operated on

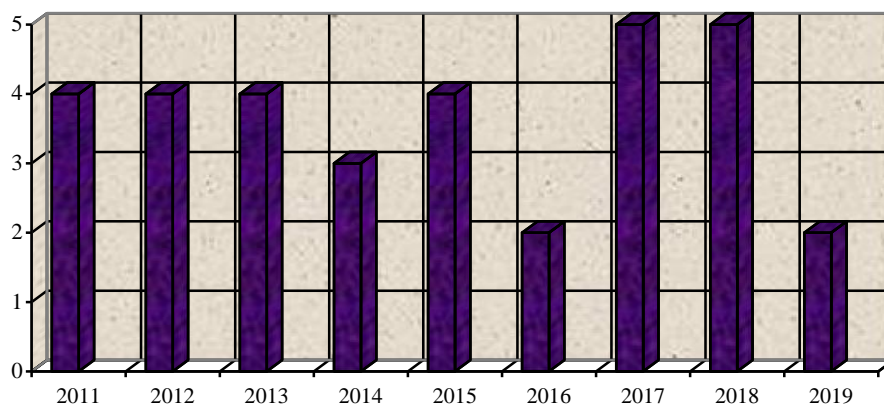


Fig. 5. Annual dynamics of all the patients with amputations

3.2. Methods

Within patients' hospitalization in the Clinic of Vascular Surgery, routine clinical, laboratory and imaging examinations were performed. After patient's history, the angiological status was specified as the values of the wrist-ankle index of the upper limb arteries and of the ankle-brachial index of the lower limb ones were determined.

In order to evaluate the blood flow in the arteries of both upper extremities, along with a symmetrical measurement of the arterial pressure in *a. brachialis*, *a. radialis*, *a. ulnaris* and in the plantar arch, we introduced the wrist-ankle index, too. It played a particularly important role in the assessment of the arterial blood flow of the upper extremities in cases of simultaneous pathology of both upper limbs and a normal blood flow in the lower ones. The wrist-ankle index was a mirror image of the ankle-brachial index. Its normal values ranged between 0,81 and 1,07 while the normal values of the ankle-brachial index were between 1,21 and 0,92. Wrist-ankle index values below 0,81 were considered pathological and represented an indication of timely performance of invasive diagnosis. The level of arterial vessel obstruction

was specified by means of peripheral contrast angiography of the affected extremity. Besides, echography and Doppler sonography were made use of.

The evaluation of the clinical results from the operative treatment of the acute ischemia of the extremities during the early and late postoperative period as well as within one year was accomplished based on three groups of criteria.

All the patients underwent surgical revascularization. It dealt with a surgical revision of the occluded arterial vessels of the upper and lower limbs. It included the usage of one or several routine operative techniques in the concrete patients such as thrombectomy, embolectomy, thromboembolectomy, thrombendarterectomy, angioplastics and/or bypass graft placement. Early revascularization (prior to the tenth hour) was performed with standard vascular accesses (femoral and popliteal in the lower or cubital - in the upper limb). Delayed revascularization (during a differently longer period of time) was carried out either with the same standard, or with both standard and distal vascular accesses (ankle of the anterior and posterior tibial artery, or wrist - of the radial and ulnar artery).

The results obtained by us were statistically processed by means of descriptive, variation (Student-Fisher's test) and graphic analysis. Statistical reliability according to Student-Fisher's *t*-criterion was read at a significance level of $p < 0,05$.

4. OWN RESULTS

4.1. Revascularization in patients with thrombosis of the arteries of the extremities

We performed thrombectomies in a total of 102 patients, 60 males and 42 females. Mean operative time amounted to $1,1 \pm 1,7$ hours (range, 60 to 140 min.), and mean hospital stay did to $4,8 \pm 1,5$ days (range, four to five days). A total of 40 patients, 25 males and 15 females underwent early revascularization with standard vascular accesses.

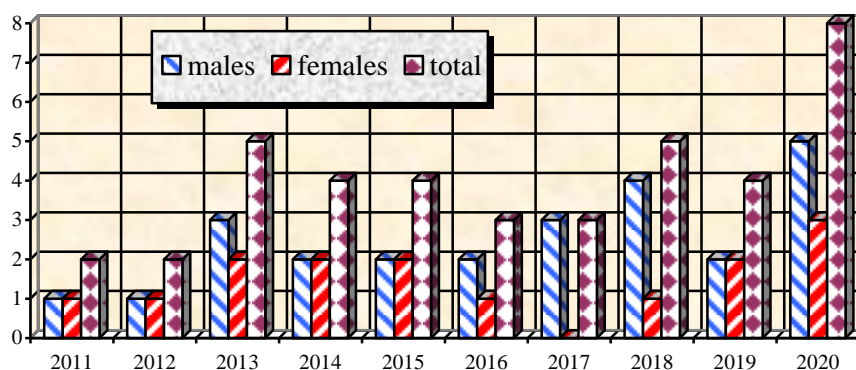


Fig. 6. Annual dynamics of early revascularization in thrombosis

The annual dynamics of early revascularization in males, females and all the patients as a whole is illustrated in Fig. 6.

A total of 27 patients, 17 males and ten females underwent delayed revascularization with standard vascular accesses. The annual dynamics of delayed revascularization with standard accesses (in sum after the 11th hour) in males, females and all the patients as a whole is demonstrated in Fig. 7.

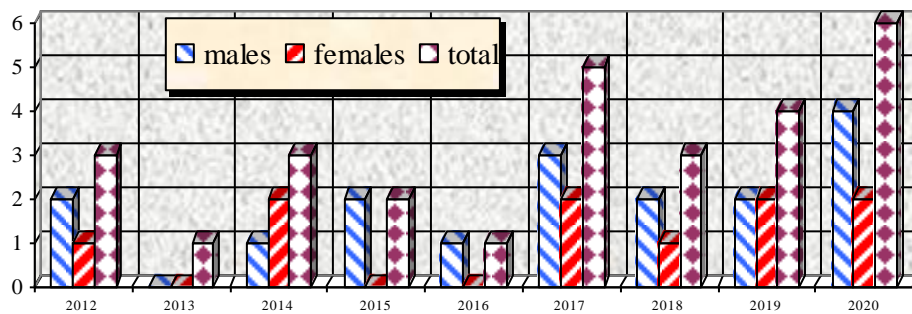


Fig. 7. Annual dynamics of delayed revascularization with standard accesses (in sum after the 11th hour)

A total of 35 patients, 18 males and 17 females underwent delayed revascularization with standard and distal vascular accesses. The annual dynamics of delayed revascularization with standard and distal accesses (in sum after the 11th hour) in males, females and all the patients as a whole is shown in Fig. 8.

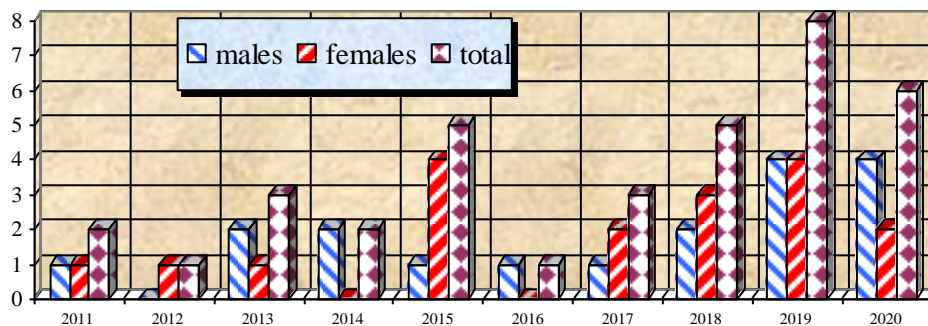


Fig. 8. Annual dynamics of delayed revascularization with standard and distal accesses (in sum after the 11th hour)

Thrombosis localization in three revascularization types is systematized in Table 1 through Table 3.

Table 1. Thrombosis localization in early revascularization

No	Artery	males	females	total
1.	popliteal	9	2	11
2.	femoral+popliteal	5	4	9
3.	femoral	3	5	8
4.	iliac	5	1	6
5.	femoral+iliac	2	3	5
6.	subclavian	1	-	1
total		25	15	40

Table 2. Thrombosis localization in delayed revascularization with standard accesses

No	Artery	males	females	total
1.	femoral	5	-	5
2.	brachial	2	3	5
3.	femoral+popliteal	3	2	5
4.	iliac	2	2	4
5.	femoral+iliac	3	-	3
6.	popliteal+brachial	1	2	3
7.	axillary	1	1	2
total		17	10	27

Table 3. Thrombosis localization in delayed revascularization with standard and distal accesses

No	Artery	males	females	total
1.	femoral	5	6	11
2.	iliac	3	3	6
3.	brachial	2	4	6
4.	popliteal	4	1	5
5.	tibial	3	-	3
6.	ulnar	-	2	2
7.	femoral+tibial	1	1	2
total		18	17	35

These three tables demonstrate data about the male and female patients as well as all the patients as a whole with early revascularization with standard vascular accesses, delayed revascularization with standard vascular accesses and delayed revascularization with standard and distal vascular accesses.

The number of males, females and all the patients as a whole having undergone early revascularization with standard vascular accesses, delayed revascularization with standard vascular accesses and delayed revascularization with standard and distal vascular accesses presenting with a different preoperative value of the ankle-brachial and wrist-ankle index on the side of damage is displayed in Table 4 through Table 8.

Table 4. Ankle-brachial index value prior to early revascularization

Ankle-brachial index value	males	females	total
0	17	8	25
0,10-0,19	3	4	7
0,20-0,29	2	2	4
0,30-0,39	2	1	3
total	24	15	39

Table 5. Ankle-brachial index value prior to delayed revascularization with standard accesses

Ankle-brachial index value	males	females	total
0	11	4	15
0,10-0,19	2	1	3
0,20-0,29	1	1	2
total	14	6	20

Table 6. Wrist-ankle index value prior to delayed revascularization with standard accesses

Wrist-brachial index value	males	females	total
0	3	5	8
0,10-0,19	1	0	1
0,20-0,29	0	1	1
total	4	6	10

Table 7. Ankle-brachial index value prior to delayed revascularization with standard and distal accesses

Ankle-brachial index value	males	females	total
0	14	9	23
0,10-0,19	1	1	2
0,20-0,29	1	1	2
total	16	11	27

Table 8. Wrist-ankle index value prior to delayed revascularization with standard and distal accesses

Wrist-brachial index value	males	females	total
0	2	4	6
0,10-0,19	0	1	1
0,20-0,29	0	1	1
total	2	6	8

After the operative intervention, the values of the ankle-brachial and wrist-ankle index increase. The number of the patients with zero and with pathologically low values decreases on the account of the number of the cases with higher values of these two indexes. The effect of the surgical revascularization is read in dependence on the levels of these values achieved. These good results are most distinctly manifested following the delayed revascularization with standard and distal accesses. Subsequently, during the control examinations, new measurements are realized and the results obtained are compared.

The postoperative results in the patients having undergone early revascularization with standard vascular accesses, delayed revascularization with standard vascular accesses and delayed revascularization with standard and distal vascular accesses are generalized as healing, status improvement and without change and systematized in Table 9 through Table 11.

Table 9. Postoperative results in early revascularization

Operation/patients	healing		with improvement	
	n	%	n	%
males	5	20,00	20	80,00
females	2	14,21	13	85,71
total	7	17,50	33	82,50

Table 10. Postoperative results in delayed revascularization with standard accesses

Operation/patients	healing		with improvement		without change	
	n	%	n	%	n	%
males	0	0	10	58,82	7	41,18
females	1	10,00	4	40,00	5	50,00
total	1	3,70	14	51,86	12	44,44

Table 11. Postoperative results in delayed revascularization with standard and distal accesses

Operation/patients	healing		with improvement	
	n	%	n	%
males	7	38,89	11	61,11
females	8	47,06	9	52,94
total	15	42,86	20	57,14

Healing is observed in a total of 23 patients (in 22,55% of the cases). It is statistically significantly more common following the delayed revascularization with standard and distal accesses than after the delayed revascularization with standard vascular accesses only ($t=3,428$; $p<0,01$). Improvement sets in in the majority of the patients having undergone surgical revascularization (in 67 patients or in 65,69% of the cases). It is most common after the early revascularization (in 82,50% of the cases). Next come the patients with delayed revascularization with standard and distal accesses and those with delayed revascularization with standard accesses. In 12 patients (in 11,76% of all the cases), no change of the status of the affected arteries has been established and that is why, in them, the performance of limb amputation is necessary. It deals only with the patients who have undergone delayed revascularization with standard accesses. Early mortality rate after the early revascularization amounted to 5,00% (one 82-year old male and one 79-year old female who has been operated on one hour after symptom occurrence).

In Table 12, the common serious accompanying diseases in all the patients with thrombosis can be seen. The leading role of the cardio-vascular diseases and type 2 diabetes mellitus is outlined. Most commonly, it deals with arterial hypertension, ischemic heart disease, and type 2 diabetes mellitus.

Table 12. Common accompanying diseases in all the patients with thrombosis

No	Disease	n	%
1.	arterial hypertension	75	73,53
2.	ischemic heart disease	53	51,96
3.	type 2 diabetes mellitus	43	42,16
4.	experienced ischemic stroke	29	28,43
5.	heart failure	18	17,65
6.	atherosclerotic myocardiosclerosis	16	15,69
7.	atrial fibrillation	11	10,78
8.	chronic obstructive pulmonary disease	6	5,88
9.	cerebro-vascular disease	6	5,88

A total of 19 common and rare accompanying diseases in males, a total of 18 ones in females and a total of 25 ones in all the patients as a whole were diagnosed. Most often, it dealt with two, three and even four serious accompanying diseases in one and the same patient each.

4.2. Revascularization in patients with embolism of the arteries of the extremities

We carried out embolectomies in a total of 117 patients, 61 males and 56 females. Mean operative time in all the patients amounted to $1,2 \pm 1,8$ hours (range, 60 to 150 min.) and mean hospital stay did to $4,9 \pm 1,4$ days (range, four to five days). A total of 33 patients, 18 males and 15 females underwent early revascularization with standard vascular accesses. The annual dynamics of this revascularization in all the patients as a whole is demonstrated in Fig. 9.

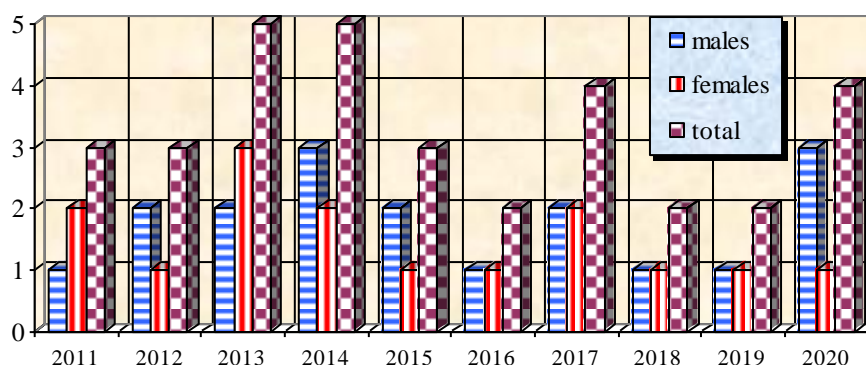


Fig. 9. Annual dynamics of early revascularization in embolism

A total of 32 patients, 17 males and 15 females underwent delayed revascularization with standard vascular accesses.

The annual dynamics of delayed revascularization with standard accesses (in sum after the 11th hour) in males, females and all the patients as a whole is presented in Fig. 10.

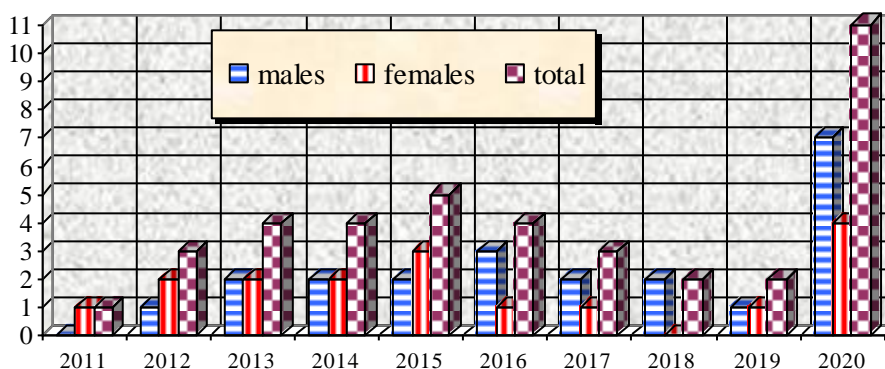


Fig. 10. Annual dynamics of delayed revascularization with standard accesses (in sum after the 11th hour)

A total of 52 patients, 26 males and 26 females underwent delayed revascularization with standard and distal vascular accesses.

The annual dynamics of delayed revascularization with standard and distal accesses (in sum after the 11th hour) in males, females and all the patients as a whole can be seen in Fig. 11.

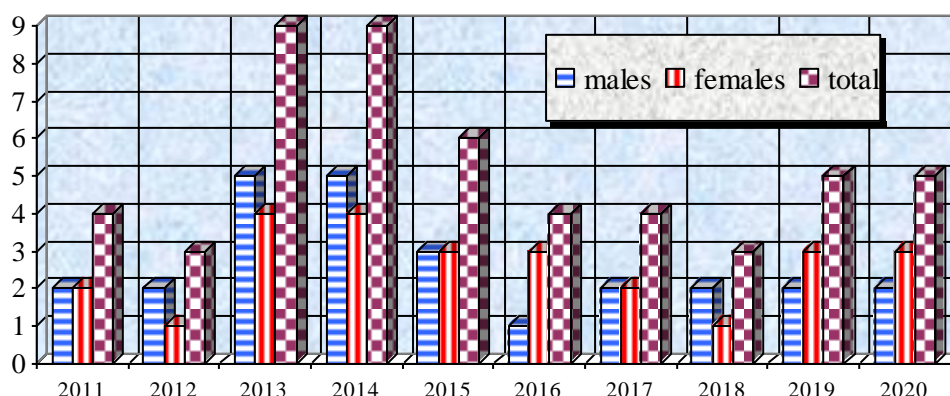


Fig. 11. Annual dynamics of delayed revascularization with standard and distal accesses (in sum after the 11th hour)

Embolism localization in the male and female patients as well as in all the patients as a whole having undergone early revascularization with standard vascular accesses, delayed revascularization with standard vascular accesses and delayed revascularization with standard and distal vascular accesses is systematized in Table 13 through Table 15.

The number of males, females and all the patients as a whole having undergone early revascularization with standard vascular accesses, delayed revascularization with standard vascular accesses and delayed revascularization with standard and distal vascular accesses presenting with a different preoperative value of the ankle-brachial and wrist-ankle index on the side of damage is shown in Table 16 through Table 21.

Table 13. Embolism localization in early revascularization

No	Artery	males	females	total
1.	femoral	7	5	12
2.	brachial	4	3	7
3.	axillary	3	3	6
4.	popliteal	1	1	2
5.	iliac	1	1	2
6.	femoral+popliteal	1	1	2
7.	subclavian	-	1	1
8.	bilateral brachial	1	-	1
total		18	15	33

Table 14. Embolism localization in delayed revascularization with standard accesses

No	Artery	males	females	total
1.	femoral	5	3	8
2.	brachial	3	2	5
3.	popliteal	2	3	5
4.	axillary	1	3	4
5.	femoral+popliteal	3	1	4
6.	iliac	1	2	3
7.	bilateral iliac	1	1	2
8.	axillary+iliac	1	-	1
total		17	15	32

Table 15. Embolism localization in delayed revascularization with standard and distal accesses

No	Artery	males	females	total
1.	femoral+mesenteric	3	6	9
2.	femoral	5	2	7
3.	iliac	4	2	6
4.	bilateral femoral	2	4	6
5.	popliteal	4	1	5
6.	femoral+axillary	2	3	5
7.	axillary	2	2	4
8.	subclavian	1	3	4
9.	tibial	1	2	3
10.	popliteal+fibular	1	1	2
11.	brachial	1	-	1
Total		26	26	52

Table 16. Ankle-brachial index value prior to early revascularization

Ankle-brachial index value	males	females	total
0	7	5	12
0,10-0,19	2	2	4
0,20-0,29	1	0	1
0,30-0,39	0	1	1
total	10	8	18

Table 17. Wrist-ankle index value prior to early revascularization

Wrist-brachial index value	males	females	total
0	4	5	9
0,10-0,19	2	1	3
0,20-0,29	2	1	3
total	8	7	15

Table 18. Ankle-brachial index value prior to delayed revascularization with standard accesses

Ankle-brachial index value	males	females	total
0	9	6	15
0,10-0,19	3	2	5
0,20-0,29	1	2	3
total	13	10	23

Table 19. Wrist-ankle index value prior to delayed revascularization with standard accesses

Wrist-brachial index value	males	females	total
0	4	3	7
0,10-0,19	1	1	2
0,20-0,29	0	1	1
total	5	5	10

Table 20. Ankle-brachial index value prior to delayed revascularization with standard and distal accesses

Ankle-brachial index value	males	females	total
0	17	13	30
0,10-0,19	4	6	10
0,20-0,29	1	2	3
Total	22	21	43

Table 21. Wrist-ankle index value prior to delayed revascularization with standard and distal accesses

Wrist-brachial index value	males	females	total
0	3	5	8
0,10-0,19	3	1	4
0,20-0,29	0	2	2
total	6	8	14

The values of the ankle-brachial and wrist-ankle index increase after the operative intervention. The effect of the surgical revascularization is read in dependence on the levels of these values achieved. Subsequently, during the control examinations, new measurements are accomplished and the results obtained are compared.

The postoperative results in the patients having undergone early revascularization with standard vascular accesses, delayed revascularization with standard vascular accesses and delayed revascularization with standard and distal vascular accesses are generalized as healing, status improvement and without change and systematized in Table 22 through Table 24.

Table 22. Postoperative results in early revascularization

Operation/patients	healing		with improvement	
	n	%	n	%
males	5	27,78	13	72,22
females	2	13,33	13	86,67
total	7	21,21	26	78,78

Table 23. Postoperative results in delayed revascularization with standard accesses

Operation/patients	healing		with improvement		without change	
	n	%	n	%	n	%
males	2	11,76	11	64,71	4	23,53
females	0	0	4	26,67	11	73,33
total	2	6,26	15	46,87	15	46,87

Table 24. Postoperative results in delayed revascularization with standard and distal accesses

Operation/patients	healing		with improvement		without change	
	n	%	n	%	n	%
males	7	26,92	17	65,39	2	7,69
females	9	34,62	13	50,00	4	15,38
total	16	30,77	30	57,69	6	11,54

Healing is observed in a total of 25 patients (in 21,37% of the cases). It is statistically significantly more commonly established after the delayed revascularization with standard and distal accesses than after the delayed revascularization with standard accesses only ($t=3,185$; $p<0,01$). Improvement sets in in most patients having undergone surgical revascularization (in 71 patients or in 60,68% of the cases). It is most common following the early revascularization (in 78,78% of the cases). Next come the patients with delayed revascularization with standard and distal accesses and those with delayed revascularization with standard accesses. In 21 patients (in 17,95% of all the cases), there is no change of the status of the affected arteries and that is why, in them, the performance of extremity amputation is necessary.

Early mortality rate after the delayed revascularization with standard accesses is 18,75% (four females and two males) but after the delayed revascularization with standard and distal accesses, it is 3,03% (one 80-year old female in whom a foot amputation has been performed, too).

In Table 25, the common serious accompanying diseases in all the patients with embolism can be seen. The leading role of the cardio-vascular diseases and type 2 diabetes mellitus was outlined.

Table 25. Common accompanying diseases in all the patients with embolism

No	Disease	n	%
1.	ischemic heart disease	101	86,32
2.	atrial fibrillation	91	77,78
3.	arterial hypertension	62	52,99
4.	atherosclerotic myocardiosclerosis	60	51,28
5.	heart failure	52	44,44
6.	type 2 diabetes mellitus	24	20,51
7.	experienced ischemic stroke	22	18,80
8.	experienced myocardial infarction	8	6,84
9.	hypertensive heart	8	6,84

A total of 25 common and rare accompanying diseases in males, a total of 23 ones in females and a total of 35 ones in all the patients as a whole were diagnosed. Most often, it dealt with two, three and even four serious accompanying diseases in one and the same patient each.

4.3. Revascularization in patients with injuries of the vessels of the extremities

Early revascularization was accomplished in 17 males and one female (between one hour and four hours after injury), delayed revascularization with standard vascular accesses was done in two males (seven hours after injury), while delayed revascularization with standard and distal vascular accesses was carried out in one male (ten days after injury).

The interval between the vascular accident and the operative intervention in all the patients is presented in Table 26.

Table 26. Interval between accident and operation

No	Interval prior to operation	n	%
1.	one hour	8	38,10
2.	two hours	5	23,82
3.	three hours	3	14,27
4.	four hours	2	9,52
5.	seven days	2	9,52
6.	ten days	1	4,77
total		21	100,00

Mean operative time in all the patients amounted to $1,4 \pm 1,9$ hours (range, 90 to 120 min.) and mean hospital stay did to $5,1 \pm 2,1$ days (range, five to six days).

The annual dynamics of the early revascularization in male patients with arterial injury is displayed in Fig. 12.

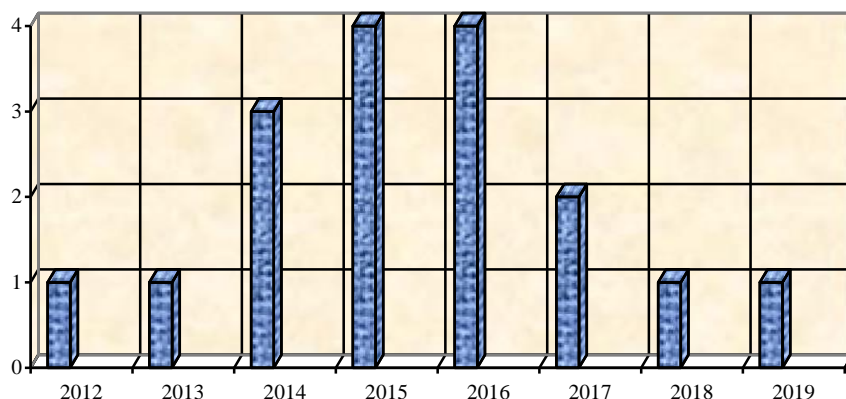


Fig. 12. Annual dynamics of early revascularization in male patients

Vascular injury localization in male patients is indicated in Table 27.

Table 27. Vascular injury localization in male patients

No	Artery	n	%
1.	right radial	6	30,00
2.	right brachial	4	20,00
3.	right radial+ulnar	3	15,00
4.	left ulnar	2	10,00
5.	right tibial	2	10,00
6.	left brachial	1	5,00
7.	right iliac	1	5,00
8.	left radial+ulnar	1	5,00
total		20	100,00

The number of all the patients as a whole with different preoperative value of the wrist-ankle index on the side of damaged artery of the upper extremity is presented in Table 28.

Table 28. Preoperative value of the wrist-ankle index

Wrist-brachial index value	males	females	total
0	12	1	13
0,10-0,19	4	0	4
0,20-0,29	1	0	1
total	17	1	18

The preoperative value of the ankle-brachial index in two males with damaged lower limb arteries is zero while this value in one male patient is 0,4. The ankle-brachial index values during the early and late postoperative period in two male patients are 0,90 each while these values in one male are 1,1 each.

An improvement of patients' clinical characteristics after the revascularization sets in already during the early postoperative period and it is better expressed during the late postoperative period.

There are neither patients with limb amputation, nor with death at all. In 12 patients with healing (in 57,14%), a complete blood flow restoration in the affected extremity and a normalization of the clinical characteristics and the parameters from the other examinations has been achieved; in eight patients with improvement (in 38,09% of the cases), there are certain residual events such as oedema, paresthesiae, etc. as well as an insufficiently restored blood flow during the control examinations, while in one patient, no improvement during the first two weeks after the operation has become apparent.

Accompanying diseases are diagnosed in a total of 13 patients. The number of the patients with these diseases and their relative share towards all the patients operated on on the occasion of vascular injury can be seen in Table 29.

Table 29. Accompanying diseases in patients with vascular injury

No	Disease	n	%
1.	arterial hypertension	8	38,10
2.	type 2 diabetes mellitus	6	28,57
3.	ischemic heart disease	4	19,05
4.	atherosclerotic myocardioclerosis	2	9,52
5.	chronic obstructive pulmonary disease	1	4,77
6.	status after coronary stenting	1	4,77

4.4. Revascularization in patients imposing the amputation of the extremity

In any patients, amputations of the extremities are imposed following the delayed revascularization. Mean operative time amounted to 1,2±0,8 hours (range, 50 to 70 min.) and mean hospital stay did to 5,0±1,2 days (range, five to six days).

The interval between the diagnosis of thrombosis and the delayed revascularization in all the patients is presented in Table 30.

Table 30. Interval between the diagnosis of thrombosis and delayed revascularization

No	Interval between diagnosis and operation	males		females		total	
		n	%	n	%	n	%
1.	two days	1	8,33	0	0	1	8,33
2.	three days	2	16,67	1	8,33	3	25,00
3.	four days	1	8,33	1	8,33	2	16,67
4.	five days	0	0	1	8,33	1	8,33
5.	seven days	1	8,33	0	0	1	8,33
6.	ten days	0	0	1	8,33	1	8,33
7.	fifteen days	1	8,33	0	0	1	8,33
8.	twenty days	1	8,33	0	0	1	8,33
9.	thirty days	0	0	1	8,33	1	8,33
total		7	58,33	5	41,67	12	100,00

The interval between the diagnosis of embolism and the delayed revascularization in all the patients is indicated in Table 31.

Table 31. Interval between the diagnosis of embolism and delayed revascularization

No	Interval between diagnosis and operation	males		females		total	
		n	%	n			n
1.	two days	0	0	2	9,52	2	9,52
2.	three days	2	9,52	3	14,29	5	23,81
3.	four days	1	4,76	1	4,76	2	9,52
4.	seven days	1	4,76	3	14,29	4	19,05
5.	ten days	1	4,76	2	9,52	3	14,29
6.	fifteen days	0	0	2	9,52	2	9,52
7.	thirty days	1	4,76	2	9,52	3	14,29
total		6	28,57	15	71,43	21	100,00

The interval between the diagnosed thrombosis and embolism and the delayed revascularization in all the patients is shown in Table 32.

Table 32. Interval between the diagnosed thrombosis and embolism and the delayed revascularization

No	Interval between diagnosis and operation	males		females		total	
		n	%	n			n
1.	two days	1	3,03	2	6,06	3	9,09
2.	three days	4	12,12	4	12,12	8	24,25
3.	four days	2	6,06	2	6,06	4	12,12
4.	five days	0	0	1	3,03	1	3,03
5.	seven days	2	6,06	3	9,09	5	15,15
6.	ten days	1	3,03	3	9,09	4	12,12
7.	fifteen days	1	3,03	2	6,06	3	9,09
8.	twenty days	1	3,03	0	0	1	3,03
9.	thirty days	1	3,03	3	9,09	4	12,12
total		13	39,39	20	60,61	33	100,00

Male and female patients' distribution with amputation of the extremity on the occasion of thrombosis having undergone delayed revascularization with standard accesses can be seen in Table 33.

Table 33. Patients' distribution with amputation on the occasion of thrombosis

Patients operated on	n	%
males	7	41,18
females	5	50,00
total	12	44,44

Patients' distribution with amputation of the extremity because of embolism with a different type of delayed revascularization can be seen in Table 34.

Table 34. Patients' distribution with amputation because of embolism according to the type of delayed revascularization

Patients operated on	standard accesses		standard and distal accesses		total	
	n	%	n	%	n	%
males	4	23,53	2	7,69	6	18,75
females	11	73,33	4	15,38	15	23,08
total	15	46,88	6	11,54	21	25,00

There are statistically significantly greater frequencies of the amputations on the occasion of embolism not only in women but also in all the patients as a whole having undergone delayed revascularization with standard accesses than in those in whom standard and distal accesses have been made use of ($t=2,584$; $p<0,05$ and $t=2,222$; $p<0,05$, respectively). The frequency of the amputations in men having undergone delayed revascularization with standard accesses is by 7,64 times greater than that in males in whom standard and distal accesses have been applied.

The total number of the amputations on the occasion of thrombosis and embolism in males, females and in all the patients as a whole having undergone delayed revascularization by means of both methods is juxtaposed in Table 35.

Table 35. Distribution of all the patients with amputation during delayed revascularization

Patients operated on	standard accesses		standard and distal accesses		total	
	n	%	n	%	n	%
males	12	35,29	1	2,27	13	16,67
females	16	64,00	4	9,30	20	29,41
total	28	47,46	5	5,75	33	22,60

The number and relative share of the amputations in male and female patients as well as in all the patients as a whole having undergone delayed revascularization with standard accesses are much greater than those in the patients whom standard and distal accesses have been used. The frequency of the amputations in all the patients as a whole is statistically reliably greater in the first than in the second group ($t=2,968$; $p<0,01$). This ascertainment convincingly proves the advantages of the delayed revascularization with standard and distal accesses that has been introduced by ourselves in the patients with acute arterial ischemia of the extremities as a consequence of thrombosis or embolism.

Vascular damage localization in males, females and all the patients as a whole having undergone limb amputation is systematized in Table 36.

In all the patients as a whole, a zero preoperative value of the ankle-brachial index on the side of damage is established.

In all the patients, several serious accompanying diseases each are diagnosed. The number and the relative share of the males, females and all the patients as a whole with these diseases are presented in Table 37.

Table 36. Vascular damage localization in all the patients with amputation

No	Artery	males		females		total	
		n	%	n	%	n	%
1.	right femoral	3	9,09	6	18,18	9	27,27
2.	right popliteal	4	12,12	2	6,06	6	18,18
3.	left femoral	1	3,03	4	12,12	5	15,15
4.	right iliac	1	3,03	3	9,09	4	12,12
5.	femoral+popliteal	2	6,06	2	6,06	4	12,12
6.	femoral+iliac	1	3,03	2	6,06	3	9,09
7.	left iliac	1	3,03	0	0	1	3,03
8.	left axillary	0	0	1	3,03	1	3,03
total		13	39,39	20	60,61	33	100,00

Among the patients with amputation because of embolism, most commonly, it dealt with heart failure, ischemic heart disease, atherosclerotic myocardiosclerosis, and atrial fibrillation while among those with amputation because of thrombosis it did with arterial hypertension, type 2 diabetes mellitus, and heart failure.

Table 37. Accompanying diseases in all the patients with amputation

No	Disease	males		females		total	
		n	%	n	%	n	%
1.	heart failure	5	38,46	9	45,00	14	42,42
2.	ischemic heart disease	2	15,38	10	50,00	12	36,36
3.	arterial hypertension	5	38,46	4	20,00	9	27,27
4.	type 2 diabetes mellitus	3	23,08	6	30,00	9	27,27
5.	atrial fibrillation	2	15,38	7	35,00	9	27,27
6.	atherosclerotic myocardiosclerosis	1	7,69	8	40,00	9	27,27
7.	hypertensive heart	1	7,69	1	5,00	2	6,06
8.	colon cancer	0	0	1	5,00	1	3,03
9.	gastric cancer	1	7,69	0	0	1	3,03
10.	stroke	0	0	1	5,00	1	3,03
11.	rheumatoid arthritis	0	0	1	5,00	1	3,03
12.	chronic obstructive pulmonary disease	1	7,69	0	0	1	3,03
13.	left posterior hemiblock	1	7,69	0	0	1	3,03
14.	anemic syndrome	1	7,69	0	0	1	3,03
15.	diabetic retinopathy	0	0	1	5,00	1	3,03

It deals with a total of six common and a total of nine rare serious accompanying diseases. In males and in females, a total of 11 accompanying diseases each are established.

The localization of the amputation of the extremity in all the patients as a whole is presented in Table 38.

Small amputations (below the knee) considerably prevail not only among the patients with thrombosis and with embolism but also among all the patients as a whole (in a total of 25 patients or in 75,76% of the cases).

Table 38. Localization of the amputation in all the patients

No	Localization	males		females		total	
		n	%	n	%	n	%
1.	below the knee	4	30,77	8	40,00	12	36,37
2.	above the knee	3	23,08	5	25,00	8	24,24
3.	through the foot	5	38,46	4	20,00	9	27,27
4.	fingers and through the foot	1	7,69	3	15,00	4	12,12
total		13	13	39,39	20	60,61	33

The total frequency of the amputations in all the patients operated on for acute ischemia of the extremities because of thrombosis or embolism amounts to 15,07%. It is higher in females (20,41%) than in males (10,74%), however, the difference is not statistically reliable ($t=1,954$; $p>0,05$).

5. DISCUSSION

5.1. Application of the operative and conservative revascularization in thrombosis of the arteries of the extremities

We performed operative revascularization on the occasion of acute ischemia of the extremities in consequence of arterial thrombosis in 60 men and 42 women. Women's mean age was by a little bit older, however, the difference between both sexes was not statistically significant ($t=1,694$; $p>0,05$). The number of the patients as a whole operated on was greatest in 2020 but smallest in 2011. The majority of the patients operated on were aged between 61 and 70 years - 21 males, 16 females and a total of 37 patients.

The number of all the patients having undergone early revascularization was greatest in 2020 but smallest in 2011 and in 2012. The number of the males having undergone delayed revascularization with standard vascular accesses (in sum after the 11th hour, between the 11th and 24th hour only and after the 24th hour only) was greatest in 2020 in sum after the 11th hour and after the 24th hour only while that of the males having undergone delayed revascularization with standard and distal vascular accesses was greatest in 2019 and in 2020 in sum after the 11th hour and in 2020 after the 24th hour only.

In all the patients as a whole, thrombosis localization in a total of eight different arteries and in four combinations of two arteries each was identified. The femoral, popliteal, and iliac arteries were most frequently affected.

The preoperative values of zero of the ankle-brachial and wrist-ankle index on the side of damage considerably prevailed in the patients having undergone the three types of revascularization. In terms of the ankle-brachial index, they were in 25 patients (in 64,10%), in 15 patients (in 75,00%) and in 23 patients (in 85,19%), while in terms of the wrist-ankle index, they were in 0%, in eight patients (in 80,00%) and in six patients (in 75,00% of the cases). After the operative intervention, the values of these two indexes increased. A substantial improvement of patients' clinical

characteristics during the early and, especially, during the late postoperative period set in.

Patients' healing was manifested by a complete blood flow restoration in the affected extremity and a normalization of the clinical characteristics and parameters of the other examinations while improvement - by some residual functional disturbances and an insufficiently restored blood flow during the control examinations. Healing was statistically significantly more often observed after the delayed revascularization with standard and distal accesses than after the delayed revascularization with standard accesses only ($t=3,428$; $p<0,01$), while improvement - in the majority of the patients, however, most commonly, after the early revascularization (in 65,69% of the cases).

A total of 19 serious accompanying diseases in males, a total of 18 ones in females and a total of 25 ones in all the patients as a whole were diagnosed, at that, most often, two, three and even four in one and the same patient each.

The effectiveness of the percutaneous mechanical thrombectomy as an initial method for thrombus removal followed by anticoagulation therapy was investigated within a retrospective study during the period between August 2016 and February 2018 in a total of 32 patients at a mean age of $68,53\pm 8,05$ years, 21 males and 11 females with acute ischemia of the extremities (L. Liu *et al.*, 2021). In all the patients, a recanalization of the thromboembolic occlusions and a complete thrombus removal was achieved. The value of the ankle-brachial index increased statistically significantly ($p<0,01$) from $0,51\pm 0,13$ prior to operation up to $0,85\pm 0,65$ immediately after the intervention and up to $0,84\pm 0,66$ three months after it.

During the period between December 2017 and December 2019, J. M. Zhuang *et al.* (2021) performed a retrospective study of 23 patients at a mean age of $69,1\pm 9,1$ years (range, 53 to 84 years), 14 men and nine women, with acute ischemia of the lower limbs having undergone a mechanical thrombectomy by means of Rotarex system. Preoperative symptoms were of a mean duration of seven days (range, six hours to 14 days). It dealt with acute thromboembolism in eight patients and with acute thrombosis in 15 ones. Lesions were localized below the groins in 16, above the groins in five, and above and below the groins in the rest two patients. Mean procedure duration was $68,2\pm 156$ min. Treatment was successful in 22 patients. Mean hospital stay was $3,6\pm 1,7$ days. The ankle-brachial index increased statistically significantly from $0,25\pm 0,10$ prior to up to $0,85\pm 0,16$ after treatment ($t=12,901$; $p<0,001$).

Contemporary trends in thrombolytic therapy in the form of initial treatment were analyzed based on the investigation of 33615 patients at a mean age of $66,2\pm 34,9$ years with acute ischemia of the extremities during the period between 2003 and 2013 (J. Bath *et al.*, 2019). Thrombolysis usage increased statistically significantly during this period (from 16,8% up to 24,2%; $p<0,0001$). Most commonly, the thrombolysis combined with endovascular procedure was made use of (in 40,7%) followed by the thrombolysis alone (in 34,1%) while most seldom - the failed thrombolysis imposing the accomplishment of the open operation (in 25,2% of the cases). Total mortality rate amounted to 4,9% and after the thrombolysis with

endovascular procedure it was statistically significantly lower (of 3,2%) than that after the thrombolysis alone (of 6,1%) and after the failed thrombolysis with open operation (of 5,9%) ($p<0,0001$).

According to the 2010 to 2014 National Inpatient Sample databases in the USA, in a total of 10484 hospitalizations for acute limb ischemia, a total of 5008 endovascular and 5476 surgical revascularizations were performed (D. Kolte *et al.*, 2020). The patients who underwent endovascular revascularization had a statistically significantly lower in-hospital mortality rate (2,8% versus 4,0%; $p=0,002$), a lower incidence rate of myocardial infarction (1,9% versus 2,7%; $p=0,022$), composite of death/myocardial infarction/stroke (5,2% versus 7,5%; $p<0,001$) as well as a statistically significantly higher incidence rate of vascular complications (1,4% versus 0,7%; $p=0,002$) compared with those undergoing surgical revascularization. Median length of stay was shorter and hospital costs were higher with endovascular versus surgical revascularization.

During the period between 2015 and 2018, O. Poursina *et al.* (2021) performed a monocentre retrospective cohort study of 60 consecutive patients at a mean age of 65 years, 39 males and 21 females with acute ischemia of the extremities. The approach with initial endovascular treatment included catheter-directed thrombolysis only in 19 patients, catheter-directed thrombolysis along with aspiration and/or rheolytic thrombectomy in 19 patients, but aspiration and/or rheolytic thrombectomy in 16 patients. Technical success was achieved in 58 patients (in 96,67% of the cases). Thirty days postoperatively, 52 patients survived (86,67%) and 53 patients had limb salvage (88,33% of the cases). Mean hospital stay lasted nine days (interquartile range, four - 14 days) and mean length of stay on the intensive care unit was two days (interquartile range, one - five days).

During the period between July 2010 and July 2016, R. de Athayde Soares *et al.* (2019) carried out in the city of Sao Paulo, Brasil, a retrospective cohort study of 69 consecutive patients with acute limb ischemia at a mean age of $75,53\pm 11,96$ years, 43 women and 26 men. Open surgery was performed in 46 patients at a mean age of $72,85\pm 8,3$ years, 28 women and 15 men, and endovascular revascularization was done in 23 patients at a mean age of $73,48\pm 7,2$ years, 15 women and eight men. Arterial hypertension was diagnosed in 62 patients, 43 in the first and 19 in the second group; diabetes mellitus - in 30 patients, 20 in the first and ten in the second group; ischemic heart disease - in 15 patients, ten in the first and five in the second group, while cardiac arrhythmias - in 16 patients, 15 in the first and one patient in the second group. The preoperative value of the ankle-brachial index in all the patients was 0,35; in those in the first group it was 0,30 and in those in the second group - 0,42 while the postoperative values of this index were 0,8; 0,9 and 0,7, respectively. The postoperative value of this index was statistically significantly higher in the first than in the second group ($p=0,03$). Total thirty-day mortality rate amounted to 10,14% (seven deceased patients). It was statistically significantly higher in the first than in the second group (six towards one lethal case; $p=0,03$) (R. de Athayde Soares *et al.*, 2019).

Endovascular revascularization was accomplished most commonly in 161 patients with acute limb ischemia in the city of Malmö, Sweden (in 68 patients or in 42,24% of the cases) (A. Kulezic & S. Acosta, 2022). Conservative therapy was applied in 25 patients (in 15,53%), open vascular revascularization - in 20 patients (in 12,42%), while a palliative treatment - in 22 patients (in 13,66% of the cases). Anticoagulation treatment was performed in 20 out of 52 patients with atrial fibrillation (in 38,46% of the cases). Amputation was imposed in 26 patients (in 16,15% of the cases).

5.2. Application of the operative and conservative revascularization in embolism of the arteries of the extremities

We performed operative revascularization on the occasion of acute ischemia of the extremities in consequence of arterial embolism in 61 men and 56 women. Women's mean age was statistically significantly older than men's one ($t=5,296$; $p<0,001$). The number of the patients as a whole operated on was greatest in 2013 and in 2014 but smallest in 2018.

The number of all the patients having undergone early revascularization was greatest in 2013 and in 2014 but smallest in 2016, in 2018 and in 2019. The number of the males having undergone delayed revascularization with standard vascular accesses was greatest in 2020 in sum after the 11th hour and after the 24th hour only while that of the males having undergone delayed revascularization with standard and distal vascular accesses was greatest in 2013 and in 2014 in sum after the 11th hour.

In all the patients as a whole, embolism localization in a total of seven different arteries and in five combinations of two arteries each was identified. The femoral artery was most commonly affected.

The preoperative values of zero of the ankle-brachial and wrist-ankle index on the side of damage considerably prevailed in the patients having undergone the three types of revascularization. Concerning the ankle-brachial index, they were in 12 patients (in 66,67%), in 15 patients (in 65,22%) and in 30 patients (in 69,67%), while concerning the wrist-ankle index, they were in nine patients (in 60,00%), in seven patients (in 70,00%) and in eight patients (in 57,14% of the cases). After the surgical intervention, the values of these two indexes increased. A substantial improvement of patients' clinical characteristics during the early and, especially, during the late postoperative period sets in.

Patients' healing was statistically significantly more often observed after the delayed revascularization with standard and distal vascular accesses than after the delayed revascularization with standard vascular accesses only ($t=3,185$; $p<0,01$), while improvent - in the majority of the patients, however, most frequently, after the early revascularization (in 78,78% of the cases).

Early mortality rate following the delayed revascularization with standard accesses was 18,75% (six lethal cases), while after the delayed revascularization with standard and distal vascular accesses it was 3,03% (one lethal case).

A total of 25 serious accompanying diseases in males, a total of 23 ones in females and a total of 35 ones in all the patients as a whole were diagnosed, at that, most often, two, three and even four in one and the same patient each.

In the retrospective investigation of 243 patients at a mean age of 77,2 years, 128 men and 115 women, with acute ischemia of the lower extremities during the period between 2007 and 2019, two independent risk factors related to embolism were established, i. e. atrial fibrillation (odds ratio of 10,26; between 5,1 and 20,67 at 95% confidence interval) and female sex (odds ratio of 5,44; between 2,76 and 10,71 at 95% confidence interval) (C. Ruiz-Carmona *et al.*, 2022).

During the period between 2012 and 2017, C. Teodoro *et al.* (2020) performed a retrospective cohort study of 37 consecutive patients at a mean age of 70 years, 25 males and 12 females, with embolism of the arteries of the extremities in a university hospital in Brasil. The accompanying diseases were arterial hypertension (in 69 patients or in 65,71%), cardiac arrhythmias (in 28 patients or in 26,67%), dyslipidemia and diabetes mellitus (in 25 patients or in 24,04% of the cases each). Thrombembolectomy using Fogarty catheter was accomplished in 30 patients (in 81,08% of the cases). A large amputation was imposed in ten patients.

A retrospective study of 20 patients at a mean age of 64 years with acute ischemia of the legs because of embolism was carried out during the period between January 2013 and December 2016 (J. Hemingway *et al.*, 2019). Endovascular revascularization was performed in four patients, simple open operation - in 16, but fasciotomy during the initial and subsequent operation - in eight and in two patients, respectively. There was one lethal case only.

Safety and effectiveness of 16 Solitaire AB devices designed for mechanical revascularization in combination with thromboaspiration were analyzed in a total of 15 consecutive patients at a mean age of $72,3 \pm 15,6$ years (range, 39 to 91 years) with acute ischemia of the lower extremities in a consequence of embolic occlusion of the popliteal and infrapopliteal artery within a monocentre retrospective investigation in China (M. Gong *et al.*, 2022). Mean duration of symptoms prior to patients' hospitalization was $2,4 \pm 1,3$ days. Arterial hypertension was diagnosed in 12 patients, diabetes mellitus and atrial fibrillation - in 11 patients each, while coronary artery disease - in four patients. A small amputation was imposed in one patient only.

A total of 20 embolectomies of the brachial artery with postoperative anticoagulation treatment were performed in 16 patients with acute severe ischemia of the upper extremities at a mean age 62,4 years (range, 30 to 92 years), 13 women and three men (P. Harnarayan *et al.*, 2021). After accomplishing the immediate reperfusion, a relief of the symptoms set in. One patient came to a lethal end.

A successful mechanical embolectomy using a distal embolic protection device was accomplished in three patients with angiographic evidence of distal embolism of the lower extremities during limb salvage endovascular procedures (M. Ibrahim *et al.*, 2022). A complete revascularization of the affected vessels without any complications or side effects was achieved.

The effect of the interval between hospitalization and performance of revascularization was analyzed within a retrospective investigation during the period

between 2008 and 2016 in a total of 138 patients at a mean age of 69 years, 90 males and 48 females, with acute limb ischemia because of embolism (M. Ben Hammamia *et al.*, 2019). Mean revascularization delay amounted to 20 hours (range, two to 240 hours). Prior to the 12th hour, 76 patients were operated on, and after it - 62 patients did. One-month morbidity rate was 5,7% but mortality one was 1,4%. Total frequency of the extremities saved was 86,9% but of the neurological consequences from the disease was 31,8%. The frequency of the neurological consequences was statistically reliably higher among the patients with more delayed revascularization (51,6% versus 15,7%; $p=0,012$).

5.3. Application of the operative and conservative revascularization in injuries of the arteries of the extremities

During the period between 2012 and 2019, we performed operative revascularization on the occasion of acute limb ischemia in consequence of arterial injury in 20 men and one woman. The number of the males operated on was greatest in 2015 and in 2016. Early revascularization was accomplished in 17 males and one female (in 85,72%), delayed revascularization with standard vascular accesses - in two males (in 9,52%) but delayed revascularization with standard and distal vascular accesses - in one male (in 4,76% of the cases).

The interval between the vascular accident and the operative intervention was comparatively short - one hour only in eight and two hours only - in five patients. Most commonly, upper limb arteries were injured (in 17 patients or in 85,00% of the cases). One man presented with a combined injury of the right radial artery and the right median nerve. Damages of the radial, ulnar, and brachial artery prevailed.

There was a preoperative value of zero of the wrist-ankle index in 13 patients (in 72,22%) but of the ankle-brachial index - in two patients (in 66,67% of the cases).

Patients' clinical characteristics improved already during the early postoperative period and this improvement was more clearly manifested during the late postoperative period. There were no patients with extremity amputation and death. Healing was achieved in 12 patients (in 57,14%) and improvement - in eight ones (in 38,09% of the cases). In a total of 13 patients, six serious accompanying diseases were diagnosed, predominantly arterial hypertension, type 2 diabetes mellitus, and ischemic heart disease.

During the period between 2013 and 2016, J. R. Hurd *et al.* (2020) carried out a retrospective monocentre study of 68 patients with traumatic acute ischemia of the upper and lower extremities imposing revascularization. Vascular injury of the upper limb was most often in the axillary and brachial area while that of the lower limb was in the femoral and popliteal area (in 88% and in 69% of the cases, respectively). Open surgical procedures prevailed and average number of operations was three. Mean hospital stay was 11 days. None or minimal functional deficiencies following the injury of the upper extremities were observed in 57%, significant deficiencies - in 33% and amputation - in 10%, while after the injury of the lower limbs - in 68%, 6% and 26% of the cases, respectively.

Medium-term results from the endovascular restoration of the injured popliteal arteries during the period between January 2012 and February 2020 were analyzed in 46 patients, in ten of whom presenting with penetrating and in 36 ones - with blunt injuries (C. Jiang *et al.*, 2021). Technical success was achieved in all the patients as in 24 of them, an antegrade while in the rest 22 ones, a competitive retrograde access was made use of. Mean interval between popliteal artery injury and blood flow restoration lasted $10,6 \pm 4,9$ hours, and mean operative time was $54,9 \pm 10,0$ min. Total frequency of saved extremities was 89,1%.

During the period between 2015 and 2018, B. R. Zambetti *et al.* (2022) investigated the influence of the endovascular stenting applied in 427 out of a total of 737 patients (in 57,98% of the cases) with traumatic damage of the subclavian artery. It dealt with penetrating injury in 287 patients (in 38,94% of the cases). Endovascular restoration was related to a statistically significantly lower morbidity rate (12% versus 22%; $p=0,028$) and mortality rate (6% versus 21%; $p=0,001$) in the patients with penetrating injury of the subclavian artery. According to the results from the multivariation logistic regression analysis, this restoration was the only modifiable risk factor related to the reduced mortality rate among the patients operated on for this injury (odds ratio of 0,35; between 0,14 and 0,87 at 95% confidence interval).

5.4. Amputation of the extremity after operative revascularization

During the period between 2011 and 2019, we performed delayed operative revascularization on the occasion of acute limb ischemia because of thrombosis or embolism imposing amputation in 13 males and 20 females. The number of all the patients as a whole having undergone amputation of the extremities was greatest in 2017 and in 2018.

The interval between the diagnosis of thrombosis (in a total of 12 patients) and of embolism (in a total of 21 patients) and the delayed revascularization was, most often, three days. In a total of 12 patients (in 36,36% of the cases), it dealt with a considerable duration of this interval (between ten and 30 days).

In the patients with thrombosis, delayed revascularization with standard accesses was accomplished only. This revascularization was performed in 15 patients, while delayed revascularization with standard and distal accesses was done in six patients with embolism. The frequency of the amputations in the females with embolism having undergone delayed revascularization with standard accesses was statistically significantly higher than that in those with applied standard and distal accesses ($t=2,584$; $p<0,05$). In all the patients with amputations as a whole, a statistically significant difference between the application of these two types of revascularization was missing ($t=1,928$; $p>0,05$).

Both embolism and thrombosis were most commonly located in the right femoral artery. In thrombosis, three different arteries such as femoral, popliteal, and iliac while in embolism, four different arteries such as femoral, popliteal, iliac, and axillary were affected. A combined damage of two arteries each was established in a total of seven patients.

In all the patients with lower limb ischemia, a preoperative value of zero of the ankle-brachial index on the side of damage was observed.

Among the patients with amputation because of thrombosis, a total of 13 serious accompanying diseases, predominantly, arterial hypertension, type 2 diabetes mellitus, and heart failure, while among those with amputation because of embolism, a total of eight serious accompanying diseases, predominantly, heart failure, ischemic heart disease, atherosclerotic myocardiosclerosis, and atrial fibrillation, but in all the patients as a whole, a total of six frequent and a total of nine rare accompanying diseases, 11 accompanying diseases each in males and in females were established.

Small amputations (below the knee) considerably prevailed in all the patients. Total frequency of the amputations was 15,07%.

Q. Aljarrah *et al.* (2019) performed a retrospective cohort study of 140 patients at a mean age of $62,9 \pm 1,1$ years, 86 men and 54 women, with large amputation of the leg because of acute and chronic limb ischemia and diabetic foot syndrome in an academic tertiary reference centre in Northern Jordan during the period between January 2012 and December 2017. The accompanying diseases included diabetes mellitus, arterial hypertension, ischemic heart disease, congestive heart failure, chronic kidney disease, stroke, Buerger's disease, and dyslipidemia. Amputations below the knee were performed in 110 but above the knee - in 30 patients. Acute limb ischemia was related to a statistically significantly greater probability to be an indication for amputation above the knee ($p=0,006$) and for a longer hospital stay during this amputation ($p=0,035$).

E. M. Arbănași *et al.* (2022) accomplished large amputations in 17 out of a total of 210 patients with acute limb ischemia in Romania (in 8,10%), but amputations during the first 30 days - in 57 patients (in 27,14% of the cases). The diagnosis of Rutherford class IIa played the role of a protective factor towards the unfavourable events in these patients. Multivariation analysis demonstrated that high basal ratios between neutrophilic cells and lymphocytes as well as between platelets and lymphocytes were independent prognostic factors for the amputation (with odds ratio of 11,09; between 5,48 and 22,42 at 95% confidence interval; $p<0,0001$ and with odds ratio of 8,97; between 4,44 and 18,16 at 95% confidence interval; $p<0,0001$, respectively).

In the course of the investigation of a total 33615 patients with acute limb ischemia carried out during the period between 2003 and 2013, the highest frequency of the amputations following the failed thrombolysis with open operation (of 11,6%) was established (J. Bath *et al.*, 2019). This frequency was statistically significantly higher than that following the thrombolysis with endovascular procedure (of 5,1%) and after the thrombolysis alone (of 5,3%) ($p<0,001$).

Catheter-directed thrombolysis in combination with endovascular intervention was accomplished in a total of 191 patients with acute ischemia of the legs, because of embolism in 36 and because of thrombosis - in 155 patients during the period between June 2012 and June 2017 in China (H. Sun *et al.*, 2019). The frequency of the amputations within a thirty-day postoperative period amounted to 8,38% (in 16 patients).

H. Bai *et al.* (2020) performed during the period between 2009 and 2018 a total of 10007 atherectomies and 27579 stentings with the purpose for revascularization in isolated femoro-popliteal diseases. After one year, atherectomy was related to a statistically significantly higher frequency of the large ipsilateral amputation (5,3% versus 4,1%; $p=0,046$) and a poorer improvement of the value of the ankle-brachial index ($0,19\pm 0,42$ versus $0,25\pm 0,4$; $p<0,001$) in comparison with stenting.

Emergency endovascular treatment using thrombolysis, aspiration thrombectomy, stenting, and balloon angioplastics was carried out in 65 men and 30 women at a mean age of 72,0 years with acute ischemia of the extremities during the period between January 2005 and December 2017 (T. Ueda *et al.*, 2021). Thirty-day amputation-free survival rate in case of artery occlusion was statistically significantly lower than that in case of graft obturation (75,2% versus 96,3%; $p=0,01$). The frequency of the amputation ($p=0,03$) and amputation-free survival rate ($p=0,03$) were statistically reliably more unfavourable among the patients with occlusion below the knee than among the rest patients.

6. CONCLUDING REMARKS

We analyzed in a comparative aspect our results from the application of the early and delayed revascularization in the patients with acute arterial ischemia of the extremities.

Our investigation was carried out in St. Panteleimon Hospital of Yambol during the period between January 1, 2011 and December 31, 2020 incl. It dealt with a total of 273 patients, 154 men and 119 women.

We accomplished revascularization in a total of 102 patients with thrombosis, 117 patients with embolism and 21 patients with injuries of the arteries of the extremities. Early revascularization (up to 11 hours after the vascular accident) with standard vascular accesses was implemented in 40 patients in the first, 33 patients in the second, and 18 patients in the third group. Delayed revascularization with standard vascular accesses was realized in 27, 32 and in two patients, respectively, and delayed revascularization with standard and distal vascular accesses - in 35, 52 patients and in one patient, respectively.

We introduced the wrist-ankle index for the evaluation of the acute arterial ischemia of the upper extremities. We achieved very good operative results not only with the early but also with the delayed revascularization with standard and distal vascular accesses. In most patients, there was blood flow restoration in the affected arteries, normalization of the values of the ankle-brachial and wrist-ankle index and improvement of patients' clinical characteristics during the early and, particularly, during the late postoperative period.

We established a great number of serious accompanying diseases - a total of 25 in the patients with thrombosis, a total of 35 in the patients with embolism and a total of six in 13 patients with injuries of the arteries of the extremities. Cardiovascular diseases and type 2 diabetes mellitus prevailed.

Amputation of the extremity was imposed in 33 patients with thrombosis and embolism of the the arteries of the extremities only as its total frequency amounted to 15,07%.

Total mortality rate established among the patients with thrombosis and embolism of the arteries of the extremities only amounted to 4,11% (nine lethal cases). Mortality rate was much higher in the patients with embolism (5,98% or seven deceased patients) than in those with thrombosis (1,96% or two deceased patients).

The new algorithm of behaviour in the patients with delayed revascularization of the extremities with acute arterial ischemia elaborated by ourselves is applicable in the clinical practice in our country.

We could draw the generalization that the method of the delayed revascularization with standard and distal vascular accesses applied by us in the course of the individualized operative approach has a sufficient effectiveness and safety in elderly patients with acute arterial ischemia of the extremities and deserves a wide application in the clinical practice.

7. CONCLUSIONS

Based on the investigation performed by us the following main **conclusions** can be drawn:

1. The delayed revascularization with standard and distal vascular accesses surpasses the delayed revascularization with standard vascular accesses in the treatment of the acute arterial ischemia of the extremities.

2. A reduction of the number of the amputations in the patients operated on with standard and distant accesses has been observed as the amputation level moves away in a distal direction - towards the shank, foot and toes.

3. Doppler sonography and examination of the ankle-brachial and wrist-ankle index play a substantial diagnostic and prognostic role in the patients with acute arterial ischemia of the extremities.

4. The application of the early revascularization with standard vascular accesses and the delayed revascularization with standard and distal vascular accesses in the patients with thrombosis and embolism of the arteries of the extremities is sufficiently effective and safe.

5. The diagnosed serious accompanying cardiovascular diseases play an important role during the operative behaviour.

8. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

1. **Runkov R.** Revascularization in limb arterial thrombosis. *Varna Medical Forum*, 2022;11(2):60-66 (in Bulgarian).
2. **Runkov R.** Revascularization in acute limb arterial embolism. *Varna Medical Forum*, 2022;11(2):67-73 (in Bulgarian).
3. **Runkov R, Runkov D, Domuschieva E.** Approach optimization in patients with acute arterial insufficiency through delayed revascularization techniques. *MEDICAL Magazine*, 2022;(2):78-80 (in Bulgarian).

9. CONTRIBUTIONS OF THE DISSERTATION

The contributions of the present dissertation are original scientifically applicable and of confirmatory nature.

9.1. Original scientifically applicable contributions

1. A new Doppler sonographic index, a wrist-ankle index, for assessment of the blood flow in the arteries of the upper extremities has been introduced.
2. A new algorithm of behaviour in the patients with delayed revascularization of the extremities with acute arterial ischemia has been created.

9.2. Contributions of confirmatory nature

1. A higher percentage of salvage of the extremities with a severe acute arterial ischemia has been achieved.
2. The amputation level in the patients with acute arterial ischemia of the extremities has been lowered.
3. A routine surgical revision of the affected foot and wrist arteries has been introduced.
4. The quality and effectiveness of the delayed vascular surgical interventions have been enhanced.