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CLINIC OF VASCULAR SURGERY**

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**OPERATIVE TREATMENT OF CAROTID
ARTERIES IN MULTIFOCAL
ATHEROSCLEROSIS**

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ABBREVIATIONS USED

AG	angiography
ACB	aortocoronary bypass
AH	arterial hypertension
ASA	American Society of Anesthesiologists
CAIE	chronic arterial insufficiency of the extremities
CT	computed tomography of head/brain
CTACG	computed tomography-assisted carotidography
DM	type 2 diabetes mellitus
Doppler	Doppler sonography of the carotid arteries
<i>et al.</i>	et alierte
fig.	figure
IHD	ischemic heart disease
IS	ischemic stroke

1. INTRODUCTION

Atherosclerosis is a chronic and progressive multifocal disease of the arterial wall which continues to be the main cause for acute and life-threatening cerebrovascular diseases worldwide. The pathological process is fed up predominantly by the local and systemic inflammation and provokes acute ischemic attacks after laceration of the atherosclerotic plaque and obturation of the blood vessels.

Independently of the huge advance in the field of timely and precise patients' diagnosis and complex management such as medicamentous, non-invasive, operative or combined, the results achieved do not meet at a sufficient extent the enhanced expectations and requirements of society yet.

According to the new concept, it deals with one disease in one and the same patient necessitating the complex diagnostic and therapeutic behaviour on the side of different specialists such as cardiologists, cardiac surgeons, neurologists, neurosurgeons, angiologists and vascular surgeons.

There exists a considerable advance in terms of the elaboration and more and more mass application of new and much more effective methods and their improved modifications for the operative treatment of the patients with carotid artery atherosclerosis. In general, two surgical methods are born in mind, i.e. carotid endarterectomy and carotid stenting with angioplastics. The number of the publications devoted to the most actual problems of the social epidemiology, complex diagnosis, the results from the conservative and operative treatment and its economic aspects, the serious accompanying diseases and individual patients' quality of life uninterruptedly increases.

The results from the systematic survey of the Bulgarian and foreign literature during the last years available outline a series of insufficiently well clarified practical issues among the patients with specific atherosclerotic alterations in the carotid arteries which are manifested at a different degree on the background of the multifocal atherosclerosis in terms of the optimization of the therapeutic behaviour in these patients.

On the grounds of this, we decided to perform the present complex investigation in order to outline the concrete significance of the contemporary imaging diagnosis and the effectiveness of the individualized application of the carotid endarterectomy and the carotid stenting with angioplastics in the patients with damaged carotid arteries.

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 carotid endarterectomy and the carotid stenting with angioplastics in the patients with carotid atherosclerosis.

The tasks for accomplishment of this purpose are the following:

1. To analyze the diagnostic and prognostic value of the contemporary imaging diagnosis in the patients with damaged carotid arteries.

2. To retrospectively analyze the results from the independent application of the carotid endarterectomy in the patients with a different severity of carotid artery stenosis.

3. To retrospectively analyze the results from the independent application of the carotid stenting with angioplastics in the patients with a different severity of carotid artery stenosis.

4. To retrospectively analyze the results from the application of the additional operative interventions in the patients with affection of other vascular basins.

5. To outline the role of the serious accompanying diseases for the choice of treatment and the short- and medium-term results achieved.

6. To identify the concrete advantages of the operative treatment in the patients with carotid atherosclerosis.

3. MATERIAL AND METHODS

3.1. Material

We analyzed retrospectively the documentation of all the consecutive patients with a different degree of carotid atherosclerosis hospitalized and operated on in the Clinic of Vascular Surgery of the Department of Cardiovascular Surgery and Angiology at the Medical University 'Prof. Paraskev Stoyanov' of Varna during the period between January 1, 2013 and November 30, 2020 inclusive. In the concrete patients, we made use of one of both modern methods of surgical treatment of this life-threatening pathological condition, i.e. of the carotid endarterectomy and the carotid stenting with angioplastics.

It deals with a total of 199 patients at a mean age of $65,72 \pm 6,12$ years (range, 45 to 88 years), of whom there are 135 males at a mean age of $65,28 \pm 6,56$ years (range, 47 to 79 years) and 64 females at a mean age of $66,65 \pm 8,97$ years (range, 45 to 88 years).

A total of 107 carotid atherosclerosis patients at a mean age of $65,92 \pm 7,59$ years (range, 47 to 88 years) undergo carotid endarterectomy. It deals with 70 males at a mean age of $64,51 \pm 6,62$ years (range, 47 to 79 years) and 37 females at a mean age of $68,36 \pm 9,14$ years (range, 51 to 88 years).

Among males, the patients aged between 61 and 75 years prevail, i.e. 52 or 74,29%, while among females, those aged between 66 and 80 years prevail, i.e. 22 or 59,46% of the cases.

A total of 92 carotid atherosclerosis patients at a mean age of $64,41 \pm 6,97$ years (range, 45 to 84 years) undergo carotid stenting with angioplastics. It deals with 65 males at a mean age of $65,73 \pm 6,17$ years (range, 49 to 77 years) and 27 females at a mean age of $64,68 \pm 8,52$ years (range, 45 to 84 years).

Among males, the patients aged between 56 and 70 years prevail, i.e. 48 or 73,85%, while among females, those aged between 61 and 75 years prevail, i.e. 19 or 70,37% of the cases.

3.2. Methods

Within the hospitalization of the patients with carotid artery stenosis due to arteriosclerosis, all the purposeful routine laboratory examinations and, in case of need, consulting examinations with corresponding specialists were performed. Preoperatively, patient's American Society of Anesthesiologists (ASA) status by anaesthesiologist was determined.

The diagnosis of the carotid artery stenosis was preoperatively proved by means of computed tomography-assisted carotidography (CTACG), Doppler sonography of the carotid arteries (Doppler), diagnostic angiography (AG), computed tomography of head/brain (CT) and some other methods of imaging diagnosis.

The carotid endarterectomy was accomplished under general intubation anaesthesia and the carotid stenting with angioplastics was carried out under local anaesthesia. Some patients underwent additional operative interventions in other vascular bassins affected by the multifocal atherosclerosis.

The serious comorbidity was assessed in all the patients. We analyzed the distribution of the most common accompanying diseases among the hospitalized patients in terms of their gender and age.

We analyzed the frequency of the concrete early postoperative complications among the patients with carotid atherosclerosis who underwent carotid endarterectomy or carotid stenting with angioplastics. We followed-up the thirty-day survival rate in all the patients, too.

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. Preoperative imaging diagnosis of damaged carotid arteries

The results obtained when making use of four diagnostic methods such as CTACG, Doppler, AG and CT are separately presented in both methods of operative treatment, i.e. of carotid endarterectomy and carotid stenting with angioplastics.

CTACG annual dynamics in all the patients having undergone carotid endarterectomy as a whole and their age distribution are illustrated in Fig. 1 and in Fig. 2.

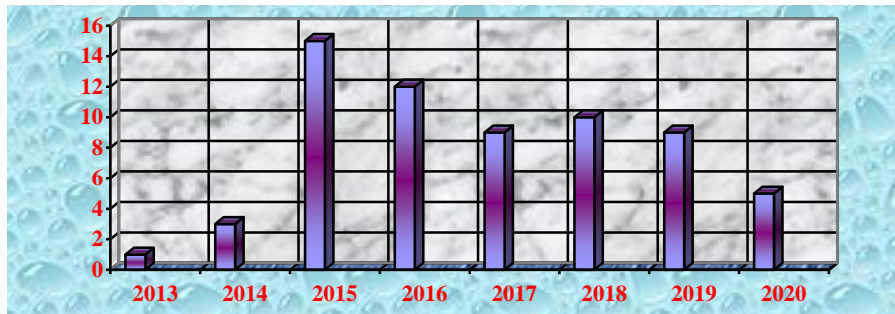


Fig. 1. CTACG annual dynamics in all the patients with carotid endarterectomy

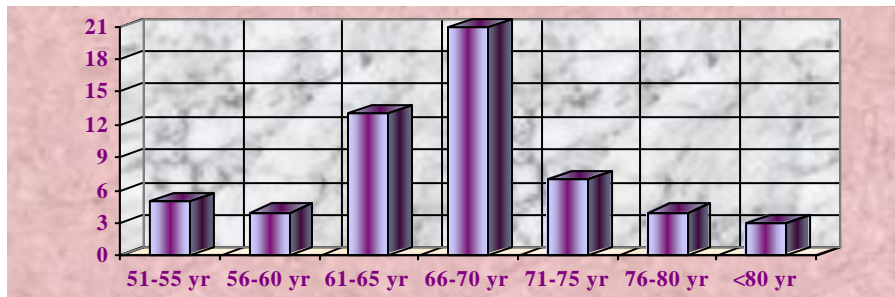


Fig. 2. Age distribution of all the patients examined by means of CTACG prior to carotid endarterectomy

Males are aged between 53 and 77 years, females are aged between 51 and 88 years while all the patients as a whole are aged between 51 and 88 years.

Doppler annual dynamics in all the patients as a whole having undergone carotid endarterectomy and their age distribution are demonstrated in Fig. 3 and in Fig. 4.

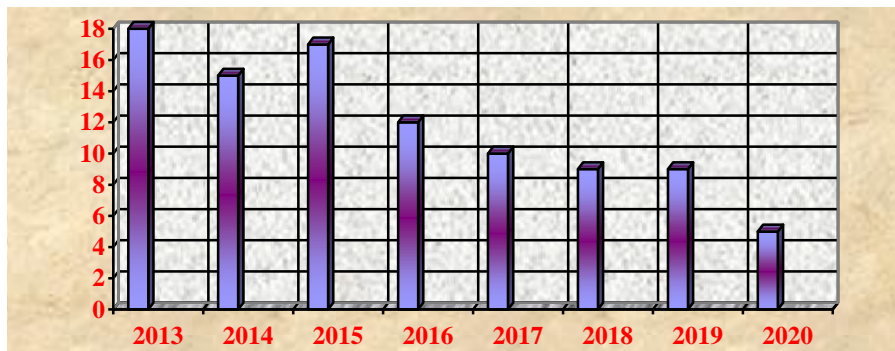


Fig. 3. Doppler annual dynamics in all the patients with carotid endarterectomy

Males are aged between 47 and 79 years, females are aged between 51 and 88 years while all the patients as a whole are aged between 47 and 88 years.

The annual dynamics and the relative share of CT and AG in male patients having undergone carotid endarterectomy can be seen in Table 1.

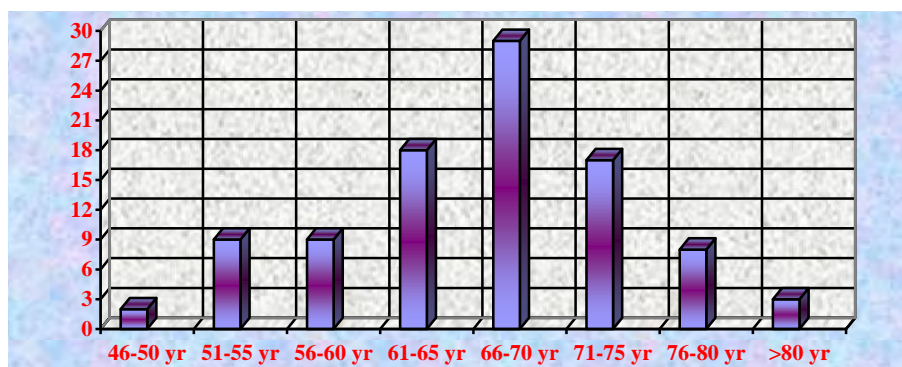


Fig. 4. Age distribution of all the patients examined by means of Doppler prior to carotid endarterectomy

Table 1. Annual dynamics and the relative share of CT and AG in male patients with carotid endarterectomy

Year	CT		AG	
	n	%	n	%
2013	2	11,76	-	-
2014	2	16,67	1	8,33
2015	2	14,29	-	-
2016	2	28,57	1	14,29
2017	1	20,00	1	20,00
2018	1	11,11	2	22,22
2019	2	50,00	-	-
Total	12	17,14	5	7,14

CTACG annual dynamics in all the patients as a whole having undergone carotid stenting with angioplastics and their age distribution are illustrated in Fig. 5 and in Fig. 6.

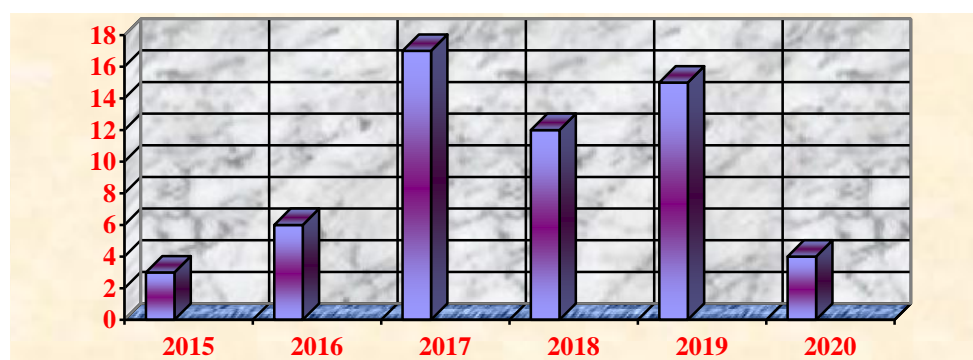


Fig. 5. CTACG annual dynamics in all the patients with carotid stenting and angioplastics

Males are aged between 49 and 77 years, females are aged between 56 and 84 years while all the patients as a whole are aged between 49 and 84 years.

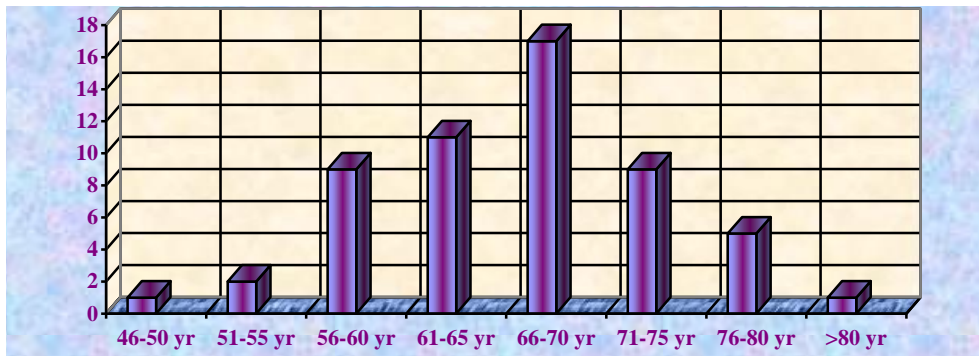


Fig. 6. Age distribution of all the patients examined by means of CTACG prior to carotid stenting with angioplastics

Doppler annual dynamics in all the patients as a whole having undergone carotid stenting with angioplastics and their age distribution are presented in Fig. 7 and in Fig. 8.

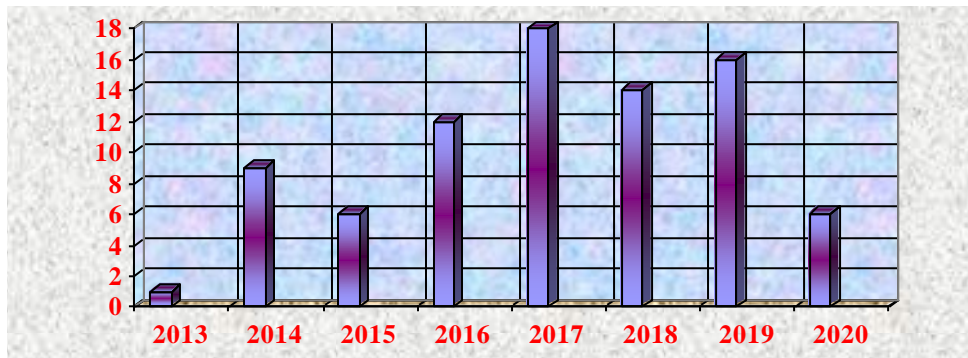


Fig. 7. Doppler annual dynamics in all the patients with carotid stenting and angioplastics

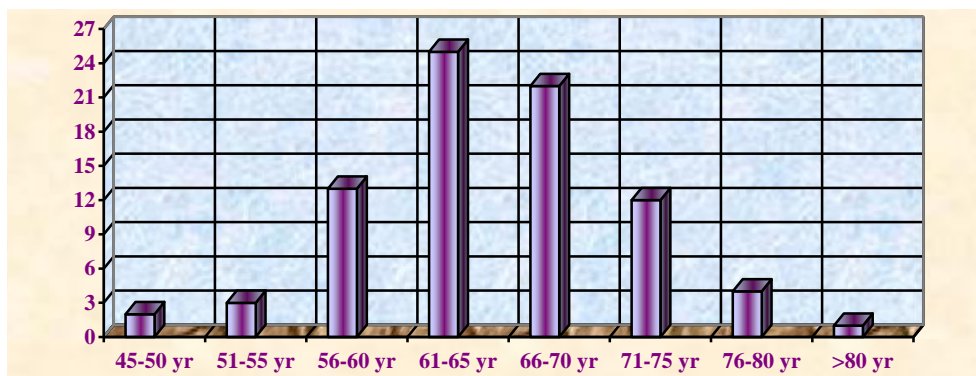


Fig. 8. Age distribution of all the patients examined by means of Doppler prior to carotid stenting with angioplastics

Males are aged between 49 and 77 years, females are aged between 45 and 84 years while all the patients as a whole are aged between 45 and 84 years.

The annual dynamics and the relative share of AG and CT in male patients having undergone carotid stenting with angioplastics are displayed in Table 2.

Table 2. Annual dynamics and relative share of AG and CT in all the patients with carotid stenting and angioplastics

Year	AG		CT	
	n	%	n	%
2013	1	100,00	-	-
2014	2	18,18	1	9,09
2015	6	75,00	3	37,50
2016	9	75,00	1	8,33
2017	19	95,00	8	40,00
2018	16	94,12	2	11,76
2019	15	88,24	-	0
2020	5	83,33	1	16,67
Total	73	79,35	16	17,39

4.2. Carotid endarterectomy application in the patients with damaged carotid arteries

During this eight-year period, we performed a total of 38 carotid endarterectomies of the right, 34 carotid endarterectomies of the left carotid artery in males as well as 20 carotid endarterectomies of the right, 18 carotid endarterectomies of the left carotid artery, three interventions of the right carotid bulb and one intervention of the the left carotid bulb in females. Besides in one 59-year old female, an intervention of the left carotid artery and the right carotid bulb became necessary while in another 73-year old female, a carotid endarterectomy of the left carotid artery in combination with carotid stenting and angioplastics of the right carotid artery and the right carotid bulb should be accomplished. We performed a carotid endarterectomy of the left carotid artery in combination with carotid stenting and angioplastics of the left carotid bulb in a 74-year old male patient. In a 63-year old male and in a 66-year-old female, we performed patch plastics of the carotid artery with stenosis only, as there was no necessity to do any carotid endarterectomy.

The annual dynamics of the carotid endarterectomy of the right and left carotid artery in all the patients as a whole is demonstrated in Fig. 9 and in Fig. 10.

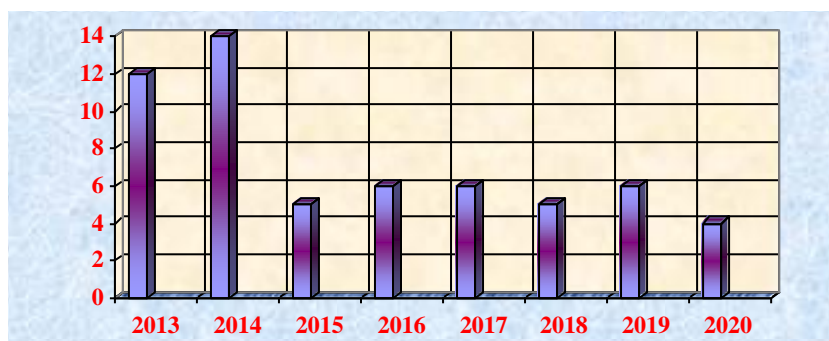


Fig. 9. Annual dynamics of the carotid endarterectomy of the right carotid artery in all the patients

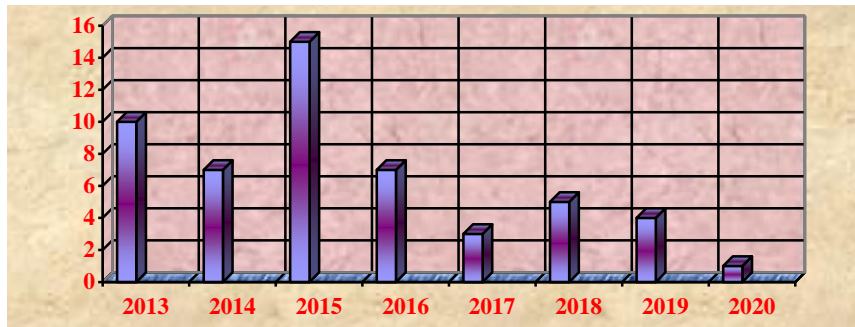


Fig. 10. Annual dynamics of the carotid endarterectomy of the left carotid artery in all the patients

The left carotid artery is operated on during the first three years in a total of 32 patients while during the last three years in a total of ten patients only. This diminution is statistically significant ($t=2,794$; $p<0,01$). Both carotid arteries are operated on during the first three years in a total of 63 patients while during the last three years in a total of 25 patients only. This reduction is statistically significant, too ($t=2,307$; $p<0,01$).

The age distributions of all the patients as a whole having undergone carotid endarterectomy of the right and left carotid artery can be seen in Fig. 11 and in Fig. 12.

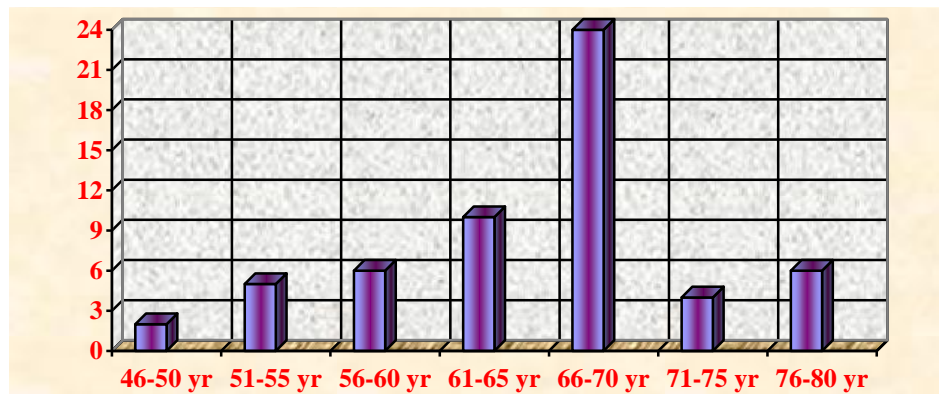


Fig. 11. Age distribution of all the patients with carotid endarterectomy of the right carotid artery

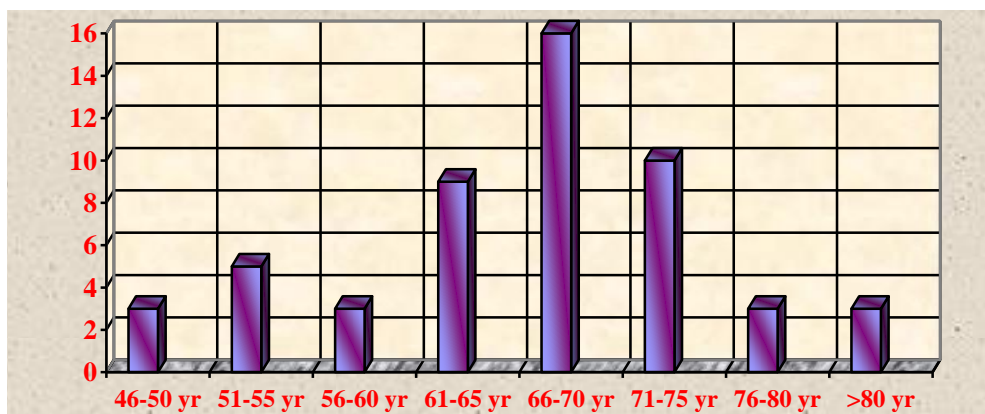


Fig. 12. Age distribution of all the patients with carotid endarterectomy of the left carotid artery

Males with operation of the right carotid artery are aged between 47 and 77 years, females are aged between 50 and 79 years and all the patients as a whole are aged between 47 and 79 years. Males with operation of the left carotid artery are aged between 50 and 77 years, females are aged between 52 and 88 years and all the patients as a whole are aged between 50 and 88 years.

Among males, the cases with ASA III (40 or 57,14%), ASA IV (15 or 21,43%) and ASA III-IV (ten or 14,29% - a total of 65 (92,86% of the cases) prevail. There are only four males with ASA II in 2013 and one male in 2016. There are no male patients with ASA I. Among females, the cases with ASA III (19 or 51,35%) and ASA IV (ten or 27,03% of the patients) prevail, too. There are only three females with ASA II (one in 2013, in 2014 and in 2019 each) and a total of five females with ASA III-IV (two in 2020 and one in 2015, in 2017 and in 2019 each). There are no female patients with ASA I.

Males with ASA III are aged between 47 and 79 years, those with ASA IV are aged between 54 and 74 years while those with ASA III-IV are aged between 53 and 77 years. Females with ASA III are aged between 51 and 88 years, those with ASA IV are aged between 58 and 82 years while those with ASA III-IV are aged between 59 and 81 years.

In all the patients having undergone carotid endarterectomy, an effective restoration of the passability of the damaged carotid arteries and carotid bulbs was achieved.

In 18 males, the following additional procedures in other vascular bassins are performed: aortocoronary bypass (ACB) of two, three or four coronary arteries, a right-side femoropopliteal bypass, treatment of an affected aortic arch bifurcation as well as stenting with angioplastics of the left and right iliac, left and right subclavian, left and right femoral artery and two coronary arteries. In one woman, ACB of one coronary artery and in another woman, stenting with angioplastics of the right subclavian artery are accomplished.

The annual dynamics of these procedures is presented in Table 3.

Table 3. Annual dynamics and relative share of the additional operative interventions among the males operated on

Year	ACB		Stenting with angioplastics		Total	
	n	%	n	%	n	%
2014	0	0	1	8,33	1	8,33
2015	2	14,86	2	14,29	4	28,57
2016	3	42,86	2	28,57	5	71,43
2017	2	40,00	1	20,00	3	60,00
2018	1	11,11	2	22,22	3	33,33
2019	0	0	1	25,00	1	25,00
2020	0	0	1	50,00	1	50,00
Total	8	11,43	10	14,29	18	33,96

These procedures are completely effective and safe.

4.3. Application of stenting with angioplastics in the patients with damaged carotid arteries

During this eight-year period, we performed a total of five stentings with angioplastics of the right and left carotid artery each and a total of 32 such interventions of the right and left carotid bulb in males as well as five stentings with angioplastics of the right and three of the left carotid artery and a total of 12 interventions of the right and nine ones of the left carotid bulb in females. Besides in seven males, an intervention of the right and left carotid bulb and in other two males, an intervention of the left carotid artery and left carotid bulb became necessary. In a 74-year old male patient, we carried out stenting and angioplastics of the left carotid bulb in combination with carotid endarterectomy of the left carotid artery.

Males having undergone stenting and angioplastics of the right and left carotid artery are aged between 59 and 69 years and between 49 and 74 years while females are aged between 46 and 69 years and between 64 and 84 years, respectively.

The annual dynamics of the stenting and angioplastics of the right and left carotid artery in all the patients as a whole can be seen in Table 4.

Table 4. Annual dynamics of the stenting and angioplastics of the right and left carotid artery in all the patients

Year	right carotid artery	left carotid artery	Total
2013	1	-	1
2014	2	1	3
2015	1	1	2
2016	2	-	2
2017	1	3	4
2018	1	2	3
2019	2	1	3
Total	10	8	18

The annual dynamics of the stenting and angioplastics of the right and left carotid bulb as well as of both carotid bulbs in all the patients as a whole is demonstrated in Fig. 13 through Fig. 15.

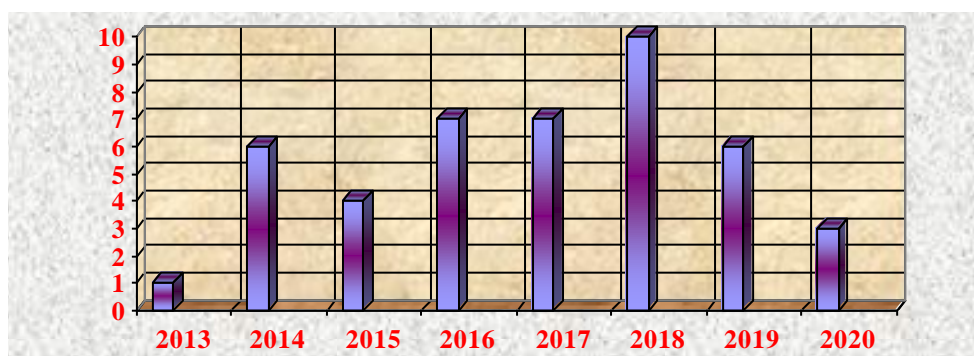


Fig. 13. Annual dynamics of the stenting with angioplastics of the right carotid bulb in all the patients

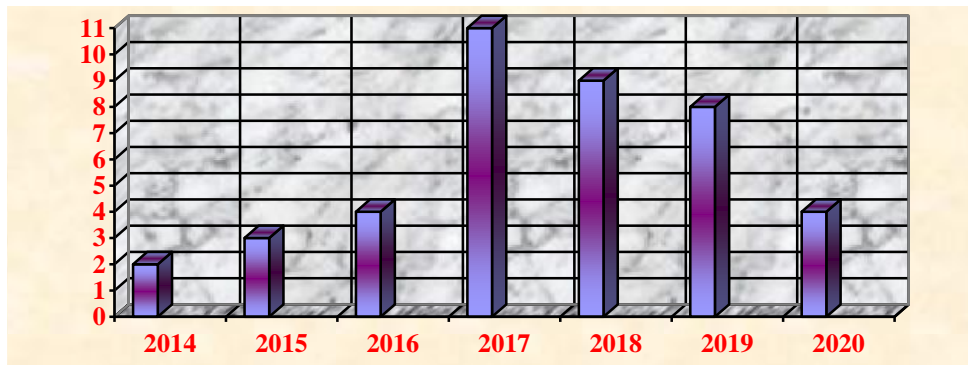


Fig. 14. Annual dynamics of the stenting with angioplastics of the left carotid bulb in all the patients

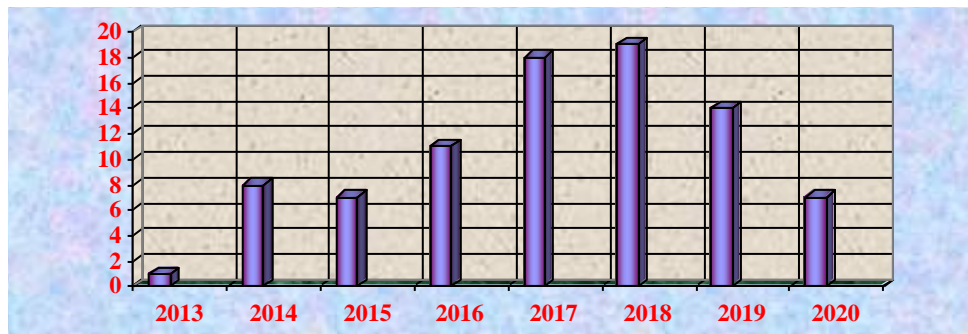


Fig. 15. Annual dynamics of the stenting with angioplastics of both carotid bulbs in all the patients

The age distributions of males having undergone stenting with angioplastics of the right and left carotid bulb and of both bulbs can be seen in Fig. 16 through Fig. 18.

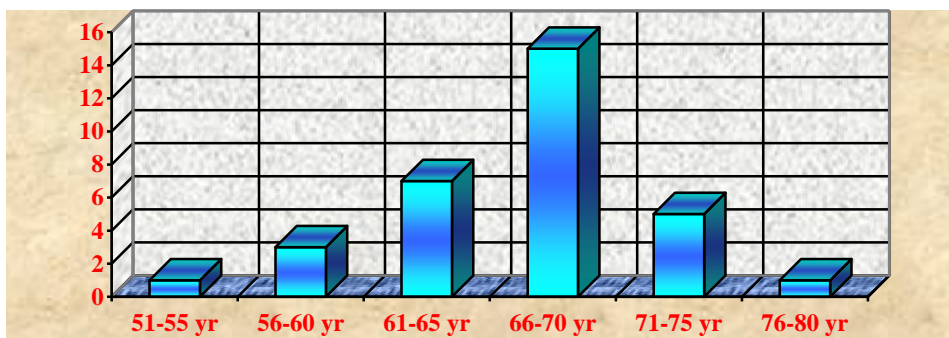


Fig. 16. Age distribution of the males with stenting and angioplastics of the right carotid bulb

Males having undergone stenting and angioplastics of the right and left carotid bulb are aged between 52 and 76 years and between 53 and 76 years while females are aged between 45 and 75 years and between 55 and 78 years, respectively. All the patients as a whole are aged between 45 and 78 years.

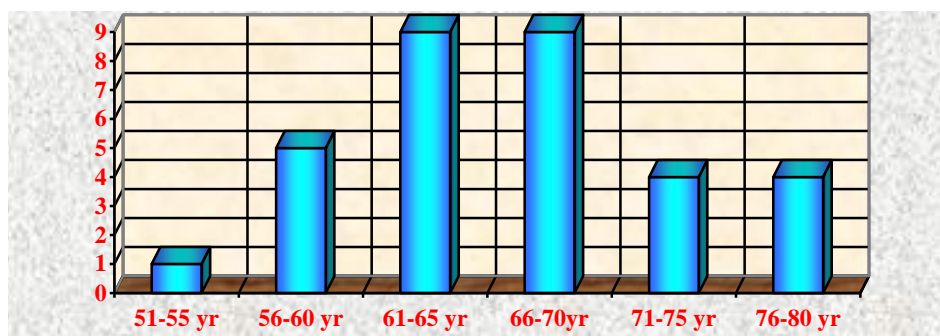


Fig. 17. Age distribution of the males with stenting and angioplastics of the left carotid bulb

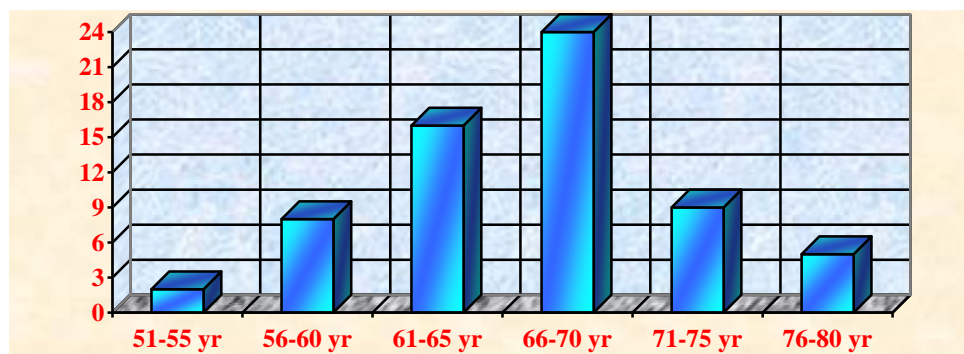


Fig. 18. Age distribution of the males with stenting and angioplastics of both carotid bulbs

Total relative share of the males having undergone this intervention of both carotid bulbs is statistically significantly greater than that of the females (98,46% versus 77,78%) ($t=2,25$; $p<0,05$).

The age distribution of females with stenting and angioplastics of both carotid bulbs (separately and in common) is displayed in Table 5.

Table 5. Age distribution of females with stenting and angioplastics of both carotid bulbs

Age group	right carotid bulb	left carotid bulb	Total
45-50 years	1	-	1
51-55 years	-	1	1
56-60 years	2	1	3
61-65 years	5	3	8
66-70 years	1	1	2
71-75 years	3	2	5
76-80 years	-	1	1
Total	12	9	21

Among males, the cases with ASA III (35 or 53,85%), ASA IV (19 or 29,23%) and ASA III-IV (nine or 13,85% of the cases) - a total of 63 (96,92% of the cases) prevail. There are only two males with ASA II in 2013. There are no male patients with ASA I. Among females, the cases with ASA III (15 or 55,56%) and ASA IV (nine or 33,33% of the patients) prevail, too. There are only two females with ASA II

(one in 2014 and in 2017 each) and one female only with ASA III-IV. There are no female patients with ASA I.

Males with ASA III are aged between 58 and 77 years, those with ASA IV are aged between 52 and 76 years while those with ASA III-IV are aged between 58 and 76 years. Females with ASA III are aged between 46 and 78 years, those with ASA IV are aged between 45 and 84 years, those with ASA II are aged between 61 and 75 years and the only one female with ASA III-IV is 69 years old.

The number and the relative share of the male patients with ASA III are greatest in 2017 and in 2018 (a total of 15 or 42,86%), of the male patients with ASA IV during the period between 2016 and 2018 (a total of 15 or 78,95%) and of the male patients with ASA III-IV in 2017 and in 2019 (a total of six patients or 66,67% of the cases with this status). The number and the relative share of the female patients with ASA III are greatest in 2019 and in 2018 (a total of seven or 46,67%) and of the female patients with ASA IV in 2019 (three or 33,33% of the cases with this status).

In all the patients having undergone stenting with angioplastics, an effective restoration of the passability of the damaged carotid arteries and carotid bulbs was achieved.

In 17 males and six females, various additional procedures in other vascular bassins are carried out. In males, it deals with ACB of two, three or four coronary arteries, aortic valve prosthesis as well as with stenting of the right carotid artery, one coronary, one left femoral artery and two iliac arteries. In one woman, ACB of four coronary arteries is performed. Stenting with angioplastics of the left femoral and popliteal artery in two women, and of the right iliac, right femoral and left femoral artery separately in one female each is accomplished.

The annual dynamics of these procedures in males is shown in Table 6.

Table 6. Annual dynamics and relative share of the additional operative interventions among the males operated on

Year	ACB		Stenting with angioplastics		Total	
	n	%	n	%	n	%
2014	0	0	0	0	1	14,29
2015	1	16,67	0	0	1	16,67
2016	1	11,11	0	0	1	11,11
2017	2	12,50	1	25,00	3	18,75
2018	4	22,22	0	0	0	0
2019	3	30,00	0	0	0	0
Total	11	18,33	1	6,25	6	10,00

These procedures are completely effective and safe.

4.4. Early postoperative complications in the patients with damaged carotid arteries

Among the patients having undergone carotid endarterectomy, there are few early postoperative complications during the period between 2014 and 2019 only at

that. It deals with nine haematomas located in the operative wound which have been revised by means of evacuation and/or haemostasis, with one ischemic stroke (IS) and with an acute inferior myocardial infarction.

During an operation on the occasion of left carotid artery stenosis, two haematomas in two males and an acute inferior myocardial infarction in a 71-year old male and one haematoma in one female are established while on the occasion of right carotid artery stenosis, two haematomas in two males and one haematoma in one female are found out. During an operation on the occasion of common carotid artery stenosis, a haematoma in one male is diagnosed; on the occasion of stenosis of the common, internal and external carotid artery, an IS in the basin of the left median cerebral artery in a 67-year old male and a haematoma in one female while on the occasion of stenosis of the common, left and external carotid artery, a haematoma in one female is detected. In the male IS patient, there are transitory ischemic attacks in the basin of the vertebrobasilar system, arterial hypertension (AH) of III degree, ischemic heart disease (ISH), chronic myocardial infarction and a stent placed two years ago while in the patient with acute inferior myocardial infarction, AH, ISH with stable angina pectoris, left ventricular heart failure, benign prostate gland hypertrophy and status post percutaneous transluminal angioplastics of the carotid arteries are revealed.

Among the patients having undergone stenting with angioplastics, three early postoperative complications are established only. It deals with a healed haematoma located in the operative wound in one female with stenting on the occasion of right carotid bulb stenosis and with lethal outcomes in two males. In one male patient with left carotid artery stenosis and against the background of the chronic left-side heart failure, AH and diabetes mellitus (DM) with complications, after stenting with angioplastics, a brainstem acute IS develops along with affection in the basin of the left median cerebral artery and lethal outcome sets in after six days. In the other male patient with left carotid bulb stenosis, a successful stenting with angioplastics has been performed in 2018, however, two years later on, during the repeated hospitalization, death sets in because of a massive pulmonary thromboembolism in the course of the intervention itself.

The early postoperative lethality rate in males established by us amounts to 1,54% and the total postoperative lethality rate is 3,08%. The incidence rate of the postoperative haematoma in women is 3,70%. The total incidence rate of the postoperative complications is 5,19% among males, 7,81% among females and 6,03% among all the patients as a whole.

4.5. Comorbidity in the patients with damaged carotid arteries

We establish the presence of a different number of common and episodic, serious chronic accompanying diseases in most patients operated on during this eight-year period.

The annual dynamics of the number of all the patients as a whole having undergone carotid endarterectomy not only without but also with a different number of accompanying diseases is summarized in Table 7.

Table 7. Annual dynamics of the number of all the patients according to the number of accompanying diseases

Year	Number of diseases/number of patients						
	0	1	2	3	4	5	6
2013	5	8	3	2	1	0	1
2014	5	6	1	3	4	0	0
2015	4	6	2	3	2	1	0
2016	3	0	2	8	1	0	1
2017	2	0	2	3	2	1	0
2018	4	1	3	0	2	0	0
2019	0	3	3	2	1	1	0
2020	0	0	2	3	0	0	0
Total	23	24	18	24	13	3	2

The annual dynamics of the relative share of all the patients having undergone carotid endarterectomy according to the number of accompanying diseases is juxtaposed in Table 8.

Table 8. Annual dynamics of the relative share of all the patients according to the number of accompanying diseases

Year	Number of diseases/percentage of patients						
	0	1	2	3	4	5	6
2013	25,00	40,00	15,00	10,00	5,00	0	5,00
2014	26,32	31,58	5,26	15,79	21,05	0	0
2015	22,22	33,33	11,11	16,67	11,11	5,56	0
2016	20,00	0	13,33	53,33	6,67	0	6,67
2017	20,00	0	20,00	30,00	20,00	10,00	0
2018	40,00	10,00	30,00	0	20,00	0	0
2019	0	30,00	30,00	20,00	10,00	10,00	0
2020	0	0	40,00	60,00	0	0	0
Total	21,50	22,43	16,82	22,43	12,15	2,80	1,87

The number and the relative share of male patients with one disease (18 or 25,71%) and with three accompanying diseases or without any accompanying disease each (15 each or 21,43% of the cases each) are greatest. The number of female patients with two (ten or 27,03%) and with three accompanying diseases (nine or 24,32% of the cases) is greatest followed by the number of those without any accompanying disease.

Most patients as a whole (24 each or 22,43% of the cases) present with one and with three accompanying diseases. Next follows the number of the patients without any accompanying disease (23 or 21,50% of the cases).

The number and the relative share of male patients with accompanying IS are by four times greater during the period between 2013 and 2015 than during the period between 2018 and 2020 (24 versus six patients and 68,57% versus 17,14% of the cases, respectively). This difference is statistically significant ($t=2,796$; $p<0,01$). The number of females with accompanying AH is greatest in 2016 and in 2019 but that

with IHD is greatest in 2016 (five patients each). Concerning all the patients as a whole, IS presents with the greatest incidence rate during the period between 2013 and 2015, IHD does during the period between 2015 and 2017 while AH does not only during this three-year period but also in 2019. IS incidence rate is statistically significantly smaller among females than among males ($t=2,231$; $p<0,05$).

The total number and the relative share of the males, females and all the patients as a whole presenting with common serious chronic accompanying diseases are indicated in Table 9 through Table 11.

Table 9. Common accompanying diseases in males

No	Accompanying disease	n	%
1.	IS	35	50,00
2.	AH	31	44,29
3.	IHD	19	27,14
4.	DM	14	20,00
5.	myocardial infarction	8	11,43
6.	heart failure	7	10,00
7.	absolute arrhythmia in atrial fibrillation	4	5,71
8.	angina pectoris	3	4,29
9.	chronic arterial insufficiency of the extremities (CAIE)	3	4,29

Table 10. Common accompanying diseases in females

No	Accompanying disease	n	%
1.	AH	19	51,35
2.	IHD	11	29,73
3.	IS	10	27,03
4.	DM	7	18,92
5.	angina pectoris	4	10,81
6.	heart failure	3	8,11
7.	myocardial infarction	3	8,11
8.	Hashimoto's autoimmune thyroiditis	3	8,11

Table 11. Common accompanying diseases in all the patients

No	Accompanying disease	n	%
1.	AH	50	46,73
2.	IS	45	42,06
3.	IHD	30	28,04
4.	DM	21	19,63
5.	myocardial infarction	11	10,28
6.	heart failure	10	9,35
7.	angina pectoris	7	6,54
8.	absolute arrhythmia in atrial fibrillation	5	4,67

The total number of the cases with three most common accompanying diseases such as AH, IS and IHD is 125; the total number of the cases with the rest 24 more rare diseases is 86 while the total number of all the cases with a total 27

accompanying diseases is 211. The relative share of the cases with these three most common accompanying diseases is considerable, i.e. 60,28% among males, 57,14% among females and 59,24% among all the patients as a whole.

The mean number of the accompanying diseases per one patient amounts to 2,01 in males, to 1,89 in females and to 1,97 in all the patients as a whole.

Glaucoma, epilepsy and vertigo are separately diagnosed in two men and one woman but gout is revealed in two men. Vertebrobasilar vascular insufficiency is detected in one man and in one woman. Separately in one male, chronic kidney failure, bladder cancer, prostate cancer, benign hypertrophy of the prostate gland, mitral valve prolapse, amaurosis, multiinfarction encephalopathy, and tachyarrhythmia are diagnosed. Bronchial asthma, diabetic polyneuropathy, cerebrovascular disease, essential thrombocytopenia, and hypercholesterolemia are separately detected in one woman. In 23 patients (in 21,50% of the cases) only, no serious chronic accompanying diseases are diagnosed at all.

The annual dynamics of the number of all the patients as a whole having undergone stenting with angioplastics not only without but also with a different number of accompanying diseases is summarized in Table 12.

Table 12. Annual dynamics of the number of all the patients according to the number of accompanying diseases

Year	Number of diseases/number of patients							
	0	1	2	3	4	5	6	9
2013	0	0	1	0	0	0	0	0
2014	4	5	0	2	0	0	0	0
2015	1	2	4	0	0	0	1	0
2016	4	1	3	2	2	0	0	0
2017	1	1	3	10	2	1	2	0
2018	0	3	3	8	1	0	2	0
2019	2	3	6	0	2	1	0	1
2020	1	1	2	0	1	0	1	1
Total	13	16	22	22	8	3	6	2

The number and the relative share of male patients with two accompanying diseases (18 or 27,69%) and with three accompanying diseases (15 each or 23,08% of the cases each) are greatest. In 2020, there is one male patient with a total of nine accompanying diseases. The number and the relative share of all the patients as a whole with two and with three accompanying diseases each (22 each or 23,91% of the cases each) are greatest. The only accompanying diseases in males are IS (in five patients) and AH (in three patients), in females they are AH (in five patients), IS (in two patients) and DM (in one patient) while in all the patients as a whole they are AH (in eight patients), IS (in seven patients) and DM (in one female patient).

The annual dynamics of the relative share of all the patients having undergone stenting according to the number of accompanying diseases is juxtaposed in Table 13.

Table 13. Annual dynamics of the relative share of all the patients according to the number of accompanying diseases

Year	Number of diseases/percentage of patients							
	0	1	2	3	4	5	6	9
2013	0	0	100,00	0	0	0	0	0
2014	36,36	45,45	0	18,18	0	0	0	0
2015	12,50	25,00	50,00	0	0	0	12,50	0
2016	33,33	8,33	25,00	16,67	16,67	0	0	0
2017	5,00	5,00	15,00	50,00	10,00	5,00	10,00	0
2018	0	17,65	17,65	47,06	5,89	0	11,76	0
2019	11,76	17,65	35,29	0	11,76	5,89	0	5,89
2020	16,67	16,67	33,33	0	16,67	0	16,67	16,67
Total	14,13	17,39	23,91	23,91	8,70	3,26	6,52	2,17

The relative share of male patients with two accompanying diseases is greatest in 2015 (66,67%) and in 2019 (50,00%), that of female patients with one accompanying disease in 2015 (100,00%), of those with two accompanying diseases in 2013 (100,00%) and of those with three accompanying diseases in 2017 (75,00%) and 2018 (60,00%). The relative share of all the patients as a whole with two accompanying diseases is greatest in 2013 and in 2015 (50,00%) and of those with three accompanying diseases in 2017 (50,00%).

The number and the relative share of male patients with accompanying AH are greatest during the period between 2017 and 2019 (25 patients or 62,50%), of those with accompanying IS during the period between 2016 and 2018 (20 patients or 62,50%), of those with accompanying IHD during the period between 2016 and 2017 (11 patients or 44,00%) while of those with accompanying DM during the period between 2017 and 2018 (ten patients or 45,45% of the cases).

The accompanying AH presents with the greatest number and the relative share not only among the female patients during the period between 2017 and 2018 (six patients or 42,86%) but also among all the patients as a whole during the period between 2017 and 2019 (36 patients or 66,67% of the cases).

The total number and the relative share of the males, females and all the patients as a whole presenting with common serious chronic accompanying diseases can be seen in Table 14 though Table 16.

Table 14. Common accompanying diseases in males

No	Accompanying disease	n	%
1.	AH	40	61,54
2.	IS	32	49,23
3.	IHD	25	38,46
4.	DM	22	33,85
5.	heart failure	8	12,31
6.	angina pectoris	8	12,31
7.	diabetic polyneuropathy	6	9,23

IS incidence rate is statistically significantly smaller among females than among males ($t=2,359$; $p<0,01$) while IHD incidence rate among females is not statistically significantly smaller than that among males ($t=0,830$; $p>0,05$).

Table 15. Common accompanying diseases in females

No	Accompanying disease	n	%
1.	AH	14	51,85
2.	IS	7	25,93
3.	DM	7	25,93
4.	IHD	6	22,22
5.	heart failure	5	18,52

Table 16. Common accompanying diseases in all the patients

No	Accompanying disease	n	%
1.	AH	54	58,70
2.	IS	39	42,39
3.	IHD	31	33,70
4.	DM	29	31,52
5.	heart failure	13	14,13
6.	angina pectoris	9	9,78
7.	diabetic polyneuropathy	6	6,52
8.	myocardial infarction	6	6,52

The total number of the cases with three most common accompanying diseases such as AH, IS and IHD is 124; the total number of the cases with the rest 28 more rare diseases is 100 while the total number of all the cases with a total 31 accompanying diseases is 224. The relative share of the cases with these three most common accompanying diseases should be outlined, i.e. 56,73% among males, 51,85% among females and 55,56% among all the patients as a whole.

The mean number of the accompanying diseases per one patient amounts to 2,61 in males, to 2,00 in females and to 2,43 in all the patients as a whole.

Cerebrovascular disease is separately diagnosed in two men and in one woman, CAIE in one male and in one female, but chronic obstructive pulmonary disease in two men. Aortic stenosis, vertigo, benign hypertrophy of the prostate gland, gout, atrial fibrillation, gastric ulcer, chronic bronchitis, a disease of the optic nerve of the right eye, and hyperlipidemia are separately diagnosed in one male. Cerebral aneurysm, lower limb varices, glaucoma, ovarian cancer, Parkinson's disease, rheumatoid arthritis, and dementia are separately detected in one female. In 13 patients (in 14,13% of the cases) only, no serious chronic accompanying diseases are established at all.

5. DISCUSSION

5.1. Role of preoperative imaging diagnosis of the damaged carotid arteries

The main imaging diagnostic methods in the patients having undergone carotid endarterectomy during this eight-year period are CTACG and Doppler.

In addition, CT and/or ASG are made use in single patients.

CTACG examination is effectively used most often in 2018 in males, in 2016 in females and in 2015 in all the patients as a whole. Most commonly, it deals with the age group between 66 and 70 years not only among males but also among females and among all the patients as a whole. Males are aged between 53 and 77 years, females are aged between 51 and 88 years and all the patients as a whole are aged between 51 and 88 years.

The relative share of the examined patients towards all the patients operated on is greatest in males (50,00% in 2018; 48,15% in 2015 and 46,88% in 2013); in females (50,00% in 2015, in 2017 and in 2019 as well as 46,67% in 2016) and in all the patients as a whole (50,00% in 2020; 48,57% in 2015 as well as 47,37% in 2018 and in 2019), respectively.

Doppler examination is effectively applied most commonly in 2013 and in 2015 in males, in 2016, in 2014 and in 2019 in females as well as in 2013, in 2015 and in 2014 in all the patients as a whole. Most commonly, it deals with the age group between 66 and 70 years among males and among all the patients as a whole as well as with the age group between 71 and 75 years among females. Males are aged between 47 and 79 years, females are aged between 51 and 88 years and all the patients as a whole are aged between 47 and 88 years.

The relative share of the examined patients towards all the patients operated on is greatest in males (50,00% in 2018 and in 2019); in females (46,46% in 2016 and 45,45% in 2019) and in all the patients as a whole (50,00% in 2018 and in 2020 and 47,37% in 2017 and in 2019), respectively.

During the period between 2013 and 2019, a total of 12 males (17,65% of the hospitalized cases during this period) are additionally examined by means of CT while during the period between 2014 and 2018, five males (10,64% of the hospitalized cases during this period) are additionally examined by means of AG.

Among the patients having undergone stenting with angioplastics during this eight-year period, the same main imaging diagnostic methods are made use of.

CTACG examination is effectively used most often in males and in all the patients as a whole in 2017 but in females in 2019. Most frequently, it deals with the age group between 66 and 70 years among males and among all the patients as a whole but with the age group between 61 and 65 years among females. Males are aged between 49 and 77 years, females are aged between 56 and 84 years and all the patients as a whole are aged between 49 and 84 years.

The relative share of the examined patients towards all the patients with stenting is greatest in males in 2015 (48,15%), in 2013 (46,88%) and in 2018 (42,86%); in females in 2019 r. (50,00%) and in all the patients as a whole in 2019 (46,88%).

Besides during the period between 2014 and 2020, a total of 51 males (78,46%) are additionally examined by means of AG and 13 males (20,00% of the hospitalized cases during this seven-year period) are additionally examined by means

of CT. During the period between 2013 and 2020, 22 females (81,48%) are examined by means of AG but only three females (11,11% of the hospitalized cases during the whole eight-year period) are examined by means of CT. As a whole, a total of 73 patients (79,35%) are examined by means of AG and a total of 16 patients (17,39% of the cases) are examined by means of CT.

The relative share of the examinations performed using AG is statistically significantly greater than that of the examinations using CT in males ($t=4,677$; $p<0,001$) and in all the patients as a whole ($t=5,849$; $p<0,001$) being much greater than that in females, too.

A thorough CT angiography examination is performed of each of the seven segments of the internal carotid artery as per Bouthillier's classification in 70 patients (R. Baz *et al.*, 2021). The intra- and extracranial internal carotid arteries have variable dimensions and length related to gender and anthropometric parameters, however, without any significant differences concerning the side and patient's age.

Within a retrospective, single-centre cohort study, the changes of intracranial haemodynamics (in middle cerebral artery flow velocity) are assessed by means of transcranial Doppler ultrasound in 318 patients at a mean age of 70,8 years prior to as well as up to the third day after carotid endarterectomy (M. Schaafsma *et al.*, 2021). The Z-scores of the first and second systolic peak are statistically significantly larger on the third postoperative day than prior to operation ($16,0\pm 1,12$ cm/s; $p<0,001$ and $7,8\pm 0,55$ cm/s; $p<0,001$, respectively). These results testify to the restoration of the normal arteriolar resistance following carotid endarterectomy.

According to the results from the analysis of the methodical guidelines concerning the diagnosis of the stenosis of the extracranial carotid arteries published during the period between 1990 and 2019, duplex sonography is the most important diagnostic modality (H. H. Eckstein *et al.*, 2020).

The imaging CT angiography features of carotid plaques and the brain magnetic resonance imaging features are analyzed in 494 patients during a retrospective cross-sectional study (H. Baradaran *et al.*, 2021). The final stroke prediction model based on this imaging method includes the intraluminal thrombus (prevalence ratio of 2,8; between 1,6 and 4,9 at 95% confidence interval; $p<0,001$), the maximum soft plaque thickness (prevalence ratio of 1,2; between 1,1 and 1,4 at 95% confidence interval; $p<0,001$) and the rim sign (prevalence ratio of 2,0; between 1,2 and 3,3 at 95% confidence interval; $p<0,007$).

5.2. Effectiveness of carotid endarterectomy in the treatment of the carotid atherosclerosis

This operative intervention of the right carotid artery is most often performed in males in 2013 and in 2014, in females in 2014 and in 2019 and in all the patients as a whole in 2014 and in 2013 but of the left carotid artery, most commonly in males and in all the patients as a whole in 2015 and in 2013 and in females in 2016 and in 2015.

The diminished carotid endarterectomy usage of the left carotid artery during the last three years in comparison with that during the first three years (from 32 patients down to ten patients operated on) is statistically significant ($t=2,794$; $p<0,01$). The reduced application of this operation in case of atherosclerotic stenosis of both carotid arteries from a total of 63 patients (58,88%) during the first three years down to a total of 25 patients (in 23,36% of the cases) during the last three years is statistically significant ($t=2,307$; $p<0,01$).

The age group between 66 and 70 years prevails not only among males (in 48,65%) and among females (in 30,00%) but also among all the patients as a whole (in 42,11% of the cases) with right carotid artery operated on. This age group prevails in the operation of the left carotid artery among males (in 37,50%) and among all the patients as a whole (in 32,00%) while among females, the age group between 71 and 75 years is most commonly affected (in 22,22% of the cases).

Among our patients undergoing surgery, the cases with ASA III (40 or 57,14%), ASA IV (15 or 21,43%) and ASA III-IV (ten or 14,29% of the cases), a total 65 (92,86% of the cases) dominate. The majority of the patients with ASA III have undergone surgery during the first three years - 30 or 75% of the cases. Among females operated on, the cases with ASA III (19 or 51,35%), ASA IV (ten or 27,03%) and ASA III-IV (five or 13,51% of the cases) prevail, too.

There is a greatest relative share of the male patients with ASA III (42,11%) and with ASA IV (50,00%) as well as of the female patients with ASA IV in the age group between 66 and 70 years (30,00% of the cases with this status).

The relative share of females with ASA III in this age group and in the age group between 71 and 75 years is a total of 27,78% of the cases with this status.

In all the patients having undergone carotid endarterectomy, an effective restoration of the passability of the damaged carotid arteries and carotid bulbs was achieved.

S. H. Oushy *et al.* (2021) recommend the revascularization in the patients with symptomatic stenosis between 70% and 90% and prefer the carotid endarterectomy in case it can be accomplished within 14 days after symptom onset.

A total of 16220 patients admitted to 28 hospitals across seven countries included in an international administrative data set undergo carotid endarterectomy during the period between 2011 and 2015 (K. A. Gaba *et al.*, 2021). Mortality rate in 2118 symptomatic patients amounts to 0,24% (between 0,1% and 0,5% at confidence interval of 95%) but in 14102 asymptomatic patients it is 0,15% (between 0,1% and 0,2% at confidence interval of 95%).

Carotid endarterectomies are performed by routine patch closure in 78 and by primary closure in 48 patients during the period between January 2013 and December 2018 in a specialized university centre of vascular surgery in China (D. Liu *et al.*, 2021). Carotid clamp time ($p<0,001$) and operating time ($p<0,001$) are statistically significantly longer as well as intraoperative blood loss is statistically significantly more ($p<0,001$) when performing the first technique. The primary closure can be safely applied in internal carotid artery diameter greater than 5 mm.

M. D'Oria *et al.* (2021) perform a retrospective study in a total of 383 patients, 254 males and 129 females, with asymptomatic and symptomatic carotid artery stenosis undergoing elective carotid endarterectomy during the period between January, 2015 and December, 2019. Males are statistically significantly younger (at a mean age of $73,4 \pm 11$ years) than females (at a mean age of $76,3 \pm 10$ years) ($p=0,01$). Besides the proportion of male octogenarians is statistically significantly lower than that of females (20,4% versus 28,7%; $p=0,05$). The three-year survival estimates are statistically significantly lower for males than for females (84% versus 92%, $p=0,03$), especially at the age below 80 years (85% versus 97%; $p=0,005$). The results from multivariate Cox proportional hazards demonstrate that age (hazard ratio of 2,1; between 1,29 and 3,3 at confidence interval of 95%; $p=0,002$) and male gender (hazard ratio of 2,5; between 1,16 and 5,5 at confidence interval of 95%; $p=0,02$) are associated with increased hazards of all-cause mortality (M. D'Oria *et al.*, 2021).

5.3. Effectiveness of stenting with angioplastics in the treatment of the carotid atherosclerosis

This intervention is accomplished during the period between 2014 and 2019 of the right carotid artery in five males and during the period between 2014 and 2018 of the left carotid artery in other five males as well as during the period between 2013 and 2019 of the right carotid artery in five females and during the period between 2017 and 2019 of the left carotid artery in other three females. A total of 32 procedures of the right and left carotid bulb each in males as well as 12 interventions of the right and nine ones of the left carotid bulb in females are carried out.

Males having undergone stenting and angioplastics of the right and left carotid artery are aged between 59 and 59 years and between 49 and 74 years while females are aged between 46 and 69 years and between 64 and 78 years, respectively. All the patients as a whole are aged between 45 and 84 years.

The number of male patients and of all the patients as a whole having undergone stenting with angioplastics of the right carotid bulb is greatest in 2018 but that of the left one is in 2017. The number of the male patients and of all the patients as a whole with intervention of both carotid bulbs is greatest in 2017 and 2018 but that of the female ones is in 2019. The total relative share of the males with this intervention of both carotid bulbs is statistically significantly greater than that of the females (98,46% versus 77,78%) ($t=2,25$; $p<0,05$).

The age group between 66 and 70 years prevails among males with stenting of the right (in 46,88%), of the left (in 28,13%) and of both carotid bulbs (in 37,50% of the cases). The age group between 61 and 65 years prevails among females (with eight patients or 38,10% of the cases) mainly because of the relatively great number of interventions of the right carotid bulb.

There are greatest number and relative share of the male patients having undergone stenting with ASA III - 35 (54,69%) and with ASA IV (19 or 29,69%) as well as of the female patients - 15 (55,56%) and nine (33,33% of the cases), respectively. There are greatest number and relative share of the male patients with ASA III in 2017 and in 2018 (a total of 15 or 42,86%) and of those with ASA IV

during the period between 2016 and 2018 (a total of 15 or 78,95%) but of the female patients in 2019 and in 2018 (a total of seven or 46,67%) and in 2019 (three or 33,33% of the cases with this status).

Males with ASA III are aged between 58 and 77 years and those with ASA IV are aged between 52 and 76 years while females are aged between 46 and 78 years and between 45 and 84 years, respectively, females with ASA II are aged between 61 and 75 years and one female with ASA III-IV is 69 years old. The number and relative share of the females undergoing stenting with ASA III are greatest in the age group between 61 and 65 years (six or 40,00% of the cases with this status).

In all the patients having undergone stenting, an effective restoration of the passability of the damaged carotid arteries and carotid bulbs was achieved.

The results reported by other foreign authors during the last years are similar, too.

During the period between December 2016 and December 2019, in 39 patients with carotid artery lesions, two kinds of self-expandable covered stent grafts are applied (C. Liu *et al.*, 2021). A complete occlusion of the arteries is proved by angiography immediately after the carotid stenting in 36 patients and a partial vascular failure is revealed in two patients. Within a clinical and angiographic follow-up of 38 patients during a mean period of $11,2 \pm 2,4$ months, a complete lesion exclusion is proved in 36 of them.

The retrospective analysis of 340 carotid stenting procedures, 156 of which by transcervical approach and 184 ones through transfemoral approach performed during the period between January 2010 and December 2020 in a community hospital identifies in-hospital stroke in eight patients in the first and in four patients in the second group (in a total of 3,53% of the cases) (D. Toby *et al.*, 2021). According to data from multivariate analyses, a symptomatic lesion is associated with this stroke occurrence.

Y. Erben *et al.* (2021) examine the transradial approach safety in performing carotid artery stenting in 213 patients (in 3,9% of the cases) with carotid atherosclerosis. When juxtaposed to the transfemoral approach, a statistically significantly more seldom usage of general anaesthesia (in 1,5% versus 6,3% of the cases; $p=0,007$) and a more common application of protection against the distal embolization (in 96,75% versus 89,43% of the cases; $p=0,0004$) are established.

A total of 2777 patients admitted to 28 hospitals across seven countries included in an international administrative data set undergo carotid artery stenting during the period between 2011 and 2015 (K. A. Gaba *et al.*, 2021). Mortality rate in 307 symptomatic patients amounts to 3,26% (between 1,3% and 5,2% at confidence interval of 95%) but in 2407 asymptomatic patients it is 0,73% (between 0,4% and 1,1% at confidence interval of 95%).

5.4. Role of serious accompanying diseases in the patients with damaged carotid arteries having undergone operative treatment

The early postoperative complications during the period between 2014 and 2019 among the patients having undergone carotid endarterectomy of both carotid

arteries include nine haematomas located in the operative wound (five in males and four in females), one IS (in one male) and one acute inferior myocardial infarction (in one male). In the male IS patient, there are transitory ischemic attacks in the basin of the vertebrobasilar system, AH of III degree, ISH, chronic myocardial infarction and a stent placed two years ago while in the patient with acute inferior myocardial infarction, AH, ISH with stable angina pectoris, left ventricular heart failure, benign prostate gland hypertrophy and status post percutaneous transluminal angioplastics of the carotid arteries are diagnosed.

The early postoperative complications among the patients having undergone stenting with angioplastics include one haematoma in one woman, a brainstem acute IS in the basin of the left median cerebral artery and lethal outcome in one male as well as a massive pulmonary thromboembolism in the course of the operative intervention with a lethal outcome in another male. In the first patient with left carotid artery stenosis prior to the first stenting with angioplastics, a chronic left-side heart failure, AH and DM with complications are diagnosed while in the second patient with stenosis in the area of the left carotid bulb two years ago, a successful stenting with angioplastics was performed.

The early postoperative lethality rate in males amounts to 1,54% and the total postoperative lethality rate is 3,08%. The incidence rate of the postoperative haematoma in women is 3,70%. The total incidence rate of the postoperative complications is 5,19% among males, 7,81% among females and 6,03% among all the patients as a whole.

Several foreign authors establish a variety of postoperative complications in the patients with damaged carotid arteries.

S. K. Kakkos *et al.* (2021) perform a systematic review and meta-analysis of 25 studies involving a total of 147810 patients having undergone carotid endarterectomy or carotid artery stenting which are abstracted in *MEDLINE*, *Scopus* and *the Cochrane Library* data-bases. Of them, a total of 2557 patients undergo carotid revascularization after thrombolytic therapy. In 2076 patients, carotid endarterectomy is performed but in the rest 481 ones, carotid artery stenting is done. The total periprocedural IS incidence rate (and mortality rate, respectively) after carotid endarterectomy amounts to 5,2% (between 3,3% and 7,5% at confidence interval of 95%) but that of the intracerebral haematoma amounts to 3,4% (between 1,7% and 5,6% at confidence interval of 95%). In carotid artery stenting, it deals with a total periprocedural IS incidence rate (and mortality rate, respectively) of 14,9% (between 11,9% and 18,2% at confidence interval of 95%) but that of the intracerebral haematoma is 5,5% (between 3,7% and 7,7% at confidence interval of 95%).

A total of 610 consecutive patients with carotid artery stenosis subjected to carotid stenting during the period between December 2010 and February 2019 are clinically and radiologically followed-up for a mean duration of six years in a medical centre in Turkey (E. Köklü *et al.*, 2021). The carotid artery stenosis is symptomatic in 274 and asymptomatic in the rest 336 patients. Four procedure-related death are reported following the successful intervention (0,66%). Acute

carotid artery stent thrombosis is diagnosed in four (in 0,66%), hyperperfusion syndrome in two (in 0,33%), periprocedural major stroke in other two (in 0,33%) and periprocedural minor stroke in 12 patients (in 1,97% of the cases). The total clinical complication rates during the first 30 periprocedural days amount to 1,64% (ten asymptomatic patients) and 3,11% (19 symptomatic patients). On cranial magnetic resonance imaging, the following complications are detected: asymptomatic ipsilateral cranial microembolism (in 61 patients or in 11,64%), asymptomatic contralateral cranial microembolism (in 20 patients or in 3,28%) and bilateral asymptomatic cranial microembolism (in 23 patients or in 4,43% of the cases). Asymptomatic carotid artery restenosis is diagnosed in 24 patients (in 3,93% of the cases) (E. Köklü *et al.*, 2021).

We diagnose not only common but also episodic serious chronic accompanying diseases in most patients of ours.

In males with carotid endarterectomy, the cases with one disease each prevail (18 or 25,71%) as well as those with three accompanying diseases each or without any accompanying disease (15 each or 21,43% of the cases each). The only accompanying diseases in males are IS (in 17 patients) and AH (in one patient), in females, they are AH (in three patients), IS (in two patients) and DM (in one patient) and, totally, in all the patients as a whole, they are IS (in 19 patients), AH (in four patients) and DM (in one female patient).

In females with carotid endarterectomy, the cases with two diseases each prevail (ten or 27,03%) and those with three accompanying diseases each (nine patients or 24,32%) while in all the patients as a whole, those with one disease each and with three accompanying diseases each (24 patients each or 22,43% of the cases each).

The relative share of male patients with three accompanying diseases is greatest in 2016 (57,14%), in 2019 and in 2020 (50,00% each) as well as of those with two accompanying diseases in 2020 (50,00%); of female patients with one accompanying disease in 2018 (100,00%), of those with three accompanying diseases in 2020 (66,67%) and in 2016 (50,00%) as well as of those with two accompanying diseases in 2015 and in 2019 (50,00% each) and of all the patients as a whole with three accompanying diseases in 2020 (60,00%) and in 2016 (53,33%).

The four most common accompanying diseases in males are IS (in 35), AH (in 31), IHD (in 19) and DM (in 14 patients). The number and the relative share of males with IS are statistically significantly greater during the period between 2013 and 2015 than during the period between 2018 and 2020 ($t=2,796$; $p<0,01$). The number of females with accompanying AH is greatest in 2016 and in 2019 and with accompanying IHD in 2016 (five patients each). The incidence rate of IS among all the patients as a whole is highest during the period between 2013 and 2015, that of IHD is highest during the period between 2015 and 2017 but that of AH is highest not only during this three-year period but also in 2019. The four most common accompanying diseases in females are AH (in 19), IHD (in 11), IS (in ten) and DM (in seven patients). IS incidence rate is statistically reliably lower among females than among males ($t=2,231$; $p<0,05$).

Among all the patients as a whole, AH (in 50 patients or 46,73%), IS (in 45 patients or 42,06%), IHD (in 30 patients or 28,04%) and DM (in 21 patients or 19,63%) present with the greatest number and relative share.

The total number of the cases with AH, IS and IHD is 125; the total number of the cases with the rest 24 more rare diseases is 86 while the total number of all the cases with a total 27 accompanying diseases is 211. The relative share of the cases with these three most common accompanying diseases is considerable, i.e. 60,28% among males, 57,14% among females and 59,24% among all the patients as a whole. The mean number of the accompanying diseases per one patient amounts to 2,01 in males, to 1,89 in females and to 1,97 in all the patients as a whole. In 23 patients (in 21,50% of the cases) only, no serious chronic accompanying diseases are diagnosed at all.

In males with stenting and angioplastics, the cases with two accompanying diseases each prevail (18 or 27,69%) and with three accompanying diseases each (in 15 each or in 23,08% of the cases each). The only accompanying diseases in males are IS (in five patients) and AH (in three patients), in females, they are AH (in five patients), IS (in two patients) and DM (in one patient) and, totally, in all the patients as a whole, they are AH (in eight patients), IS (in seven patients), and DM (in one female patient).

In females with stenting and angioplastics, the cases with one accompanying disease each (in eight patients or in 29,63%) and with three accompanying diseases (in seven patients or 25,93%) while in all the patients as a whole, those with three accompanying diseases and with two accompanying diseases each prevail (in 22 patients each or in 23,91% of the cases each).

The relative share of male patients with stenting with two accompanying diseases is greatest in 2015 (66,67%) and in 2019 (50,00%); of female patients with stenting with one accompanying disease in 2015 (100,00%), of those with two accompanying diseases in 2013 (100,00%) and of those with three accompanying diseases in 2017 (75,00%) and in 2018 (60,00%) and of all the patients as a whole with two accompanying diseases in 2013 (100,00%) and of those with three accompanying diseases in 2017 (50,00%).

The four most common accompanying diseases in males are AH (in 40), IS (in 32), IHD (in 25) and DM (in 22 patients) while in females, they are AH (in 14), IS and DM (in seven each) and IHD (in six patients).

The number and the relative share of males with AH are greatest during the period between 2017 and 2019 (25 patients or 62,50%), of those with IS are during the period between 2016 and 2018 (20 patients or 62,50%), of those with IHD are during the period between 2016 and 2017 (11 patients or 44,00%) and of those with DM are during the period between 2017 and 2018 r. (ten patients or 45,45% of the cases).

The number and the relative share of females with AH are greatest during the period between 2017 and 2018 (six patients or 42,86% of the cases). IS incidence rate is statistically reliably lower among females than among males ($t=2,359$; $p<0,01$). Among all the patients as a whole, AH plays a leading role, particularly during the

period between 2017 and 2019 (with a total of 36 patients or 66,67% of the cases during these three years).

Among all the patients as a whole, AH (in 54 or 58,70%), IS (in 39 or 42,39%), IHD (in 31 or 33,70%) and DM (in 29 or 31,52% of the cases) present with greatest number and relative share.

The total number of the cases with AH, IS and IHD is 124; the total number of the cases with the rest 28 more rare diseases is 100 while the total number of all the cases with a total 31 accompanying diseases is 224. The relative share of the cases with these three most common diseases is considerable, i.e. 56,73% among males, 51,85% among females and 55,56% among all the patients as a whole. The mean number of the accompanying diseases per one patient amounts to 2,61 in males, to 2,00 in females and to 2,43 in all the patients as a whole. In 13 patients (in 14,13% of the cases) only, no serious chronic accompanying diseases are diagnosed at all.

Our results unambiguously demonstrate the diagnostic and prognostic importance of the main clinical manifestations of multifocal atherosclerosis such as IHD, angina pectoris, cerebrovascular disease, including IS, and CAIE as well among our patients with carotid atherosclerosis.

There exists a quickened interest in the issues of the chronic accompanying diseases in the patients undergoing carotid endarterectomy or stenting with angioplastics.

Within a six-year follow-up of a total of 580 consecutive patients with carotid artery stenosis, 259 of whom, 168 males and 91 females at a mean age of $67,4 \pm 8,5$ years undergo carotid endarterectomy and 321 of whom, 236 males and 85 females at a mean age of $66,9 \pm 8,4$ years undergo carotid stenting in a single centre in Eastern Slovakia during the period between 2012 and 2014, no statistically significant differences between both cohort groups in terms of mortality rate, survival times and short-term or long-term postoperative complications are found out (N. Leško *et al.*, 2021). Predictors of long-term mortality include age and DM after both operative interventions. Repeated carotid stentings only are related to a higher mortality rate.

During the follow-up for 60 months of a cohort of 194 patients with carotid stenosis having undergone carotid endarterectomy, 45 postoperative cardiovascular events are identified (I. Goncalves *et al.*, 2021). In 13 patients having undergone bilateral carotid endarterectomy, there is a statistically significant positive correlation between vulnerability index of the right and that of the left carotid plaque ($r=0,7$; $p=0,01$).

In the course of a retrospective cohort study during the period from January 2016 to June 2019, carotid stenting is performed in 50 men at a mean age of $70,50 \pm 10,72$ years and 21 women at a mean age of $73,62 \pm 11,78$ years (M. Ansuategui *et al.*, 2021). Mean follow-up of the patients with stenting is $11,28 \pm 11,28$ months. During the long-term follow-up of restenosis, there is no significant difference between both sexes in terms of its incidence (5,63% versus 1,41%; $p=0,9693$) and the necessity of reoperation (1,41% versus 1,41%; $p=0,4971$).

6. CONCLUDING REMARKS

We analyzed a total of 199 patients, 135 males and 64 females, operated on in the Clinic of Vascular Surgery of the Department of Cardiovascular Surgery and Angiology at the Medical University 'Prof. Paraskev Stoyanov' of Varna during the period between January 1, 2013 and November 30, 2020 inclusive. Carotid endarterectomy is performed in a total of 107 patients, 70 males and 37 females while stenting with angioplastics is accomplished in a total of 92 patients, 65 males and 27 females.

Computed tomography-assisted carotidography and Doppler sonography of the carotid arteries play a basic diagnostic role in our patients while diagnostic angiography and head/brain computed tomography are, most commonly, additionally applied in a definite number of patients with the purpose for further specifying the severity and localization of the pathological process.

The operative results obtained by us are very good. There is a restoration of the passability of the stenosed carotid arteries and carotid bulbs following the application of both modern surgical methods. Carotid endarterectomy is applied predominantly in damages of the carotid arteries but stenting with angioplastics is used in affection of the carotid bulbs. In a series of patients, very good results are achieved from the additional operative interventions accomplished such as aortocoronary bypass and stenting with angioplastics in other vascular bassins affected by multifocal atherosclerosis. In one patient having undergone stenting with angioplastics of the right carotid bulb, successful aortic valve prosthesis is realized, too.

Very rare complications during the early postoperative period are observed. Haematomas located in the operative wound are most common and they are successfully revised. The total incidence rate of the postoperative complications is 5,19% among males, 7,81% among females and 6,03% among all the patients as a whole.

We establish a considerable number of serious chronic accompanying diseases among our contingent. During the hospitalization related to the operative intervention, a timely and adequate conservative treatment of the most common and the more seldom accompanying diseases is performed. We also apply a screening method among the patients with affection of different vascular bassins by multifocal atherosclerosis such as coronary arteries, subclavian, iliac, femoral and popliteal arteries and aortic arch branches inclusive. An effective interdisciplinary collaboration is realized between the specialists actively involved in multifocal atherosclerosis and, more concretely, in the diagnosis, treatment and prevention of the vascular diseases such as vascular surgeons and angiologists, cardiac surgeons and cardiologists, specialists in internal medicine, neurologists, specialists in imaging diagnosis, etc.

The individualized operative approach applied by us presents with a sufficient effectiveness and safety in adult patients with carotid atherosclerosis.

7. CONCLUSIONS

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

1. Computed tomography-assisted carotidography and Doppler sonography of the carotid arteries present with a high diagnostic and prognostic value in the patients with damaged carotid arteries.

2. Independent individualized application of the carotid endarterectomy is effective and safe in the patients with carotid artery stenosis.

3. Independent individualized application of the stenting with angioplastics is effective and safe in the patients with stenosis of the carotid arteries and carotid bulbs.

4. The additional interventions carried out such as aortocoronary bypass and stenting with angioplastics in other vascular bassins affected by multifocal atherosclerosis are completely successful.

5. The numerous serious chronic accompanying diseases diagnosed play an essential role for the choice of the operative and conservative treatment.

6. The complications occurring during the early postoperative period are rare.

8. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

1. Yordanov E. Application of carotid endarterectomy in patients with carotid artery atherosclerosis. *Varna Medical Forum*, 2021;10(2) (in Bulgarian, in press).
2. Yordanov E. Our experience with stenting and angioplastics in patients with carotid artery stenosis. *Varna Medical Forum*, 2021;10(2) (in Bulgarian, in press).

9. CONTRIBUTIONS OF THE DISSERTATION

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

1. The important diagnostic and prognostic role of the computed tomography-assisted carotidography and Doppler sonography of the carotid arteries in the patients with damaged carotid arteries is confirmed.

2. The effectiveness and safety of the carotid endarterectomy in the patients with carotid artery stenosis is confirmed.

3. The effectiveness and safety of the stenting and angioplastics in the patients with carotid artery stenosis is confirmed.

4. The effectiveness and safety of the additionally performed aortocoronary bypass and stenting with angioplastics in the patients with atherosclerotic alterations in other vascular bassins is confirmed.

5. The importance of the serious chronic accompanying diseases for the choice of the operative and conservative treatment in the patients with carotid artery stenosis