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Anaesthetic Monitoring of Patients during Carotid Endarterectomy

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Abstract.

Atherosclerotic lesions of the extracranial arteries, namely the proximal portion of the internal carotid artery (ICA) are the leading cause of cerebral ischemia. Thus, surgical prevention of ischemic stroke consists in carotid endarterectomy. Considering polymorbidity in patients with atherosclerosis an anaesthetic monitoring of patients during arterial reconstruction is of great importance.

The objective of the research was to analyze the methods of intraoperative monitoring and the type of anaesthesia during carotid endarterectomy and to study their impact on the results of surgical treatment.

Materials and methods. The results of carotid endarterectomy performed in 415 patients with atherosclerotic lesions of carotid arteries were analyzed. All patients underwent carotid endarterectomy under general anaesthesia. The control of cerebral blood flow was made measuring oxygen saturation with the use of INVOS 5100 (Somanetics Corp., USA). All patients were divided into 3 groups: Group I included 102 patients being at risk of developing somatic diseases, Group II included 239 patients being at risk of developing neurological and symptomatic conditions, and Group III comprised 74 patients with neurologic impairment being at risk of developing somatic diseases. The traditional carotid endarterectomy and eversion carotid endarterectomy were performed.

Results and discussion. Due to intraoperative cerebral oximetry in 56 (13.5%) patients when compressing the common carotid artery (CCA) oxygen saturation levels were found to be decreased by 25-30%. In these patients, carotid endarterectomy was performed using an intraoperative shunt. Among patients of Group I perioperative complications were not observed. The level of perioperative ischemic complications in Group II was 2.1% while in Group III it was 4.1%. The overall mortality/complication rate was 3.9% (4.2% in Group II and 5.4% in Group III). The overall perioperative mortality rate was 1.2%.

Conclusions. General anaesthesia during carotid endarterectomy with intraoperative measurement of transcranial cerebral oxygen saturation allows us to achieve good perioperative results (the overall mortality/complication rate is 3.9%).

Problem statement and analysis of the recent research

Nowadays extracranial arterial disease is considered as risk factor for developing acute cerebrovascular disease [2, 3]. Atherosclerotic lesions of the extracranial arteries, namely the carotid artery bifurcations and proximal portion of the internal carotid artery (ICA) are the leading cause of cerebral ischemia accounting for about 75% of all cases [1]. Thus, when surgery of the extracranial arteries is needed carotid endarterectomy (CEA) is used in 90% of cases and the main goal of arterial reconstruction is surgical prevention of ischemic stroke [4].

According to the results of NASCET, ECST, ACST the performance of CEA significantly reduces the development of acute cerebrovascular disease (ACD) in patients with ICA stenosis (>70%) [3, 8]. The incidence of perioperative complications does not exceed 6% in patients with symptomatic ICA stenosis and 3% in patients with asymptomatic ICA stenosis [2].

However, multicentricity and progression of atherosclerosis should also be taken into account. Almost 60% of patients develop atherosclerotic lesions of other vascular territories (ischemic heart disease (IHD), lower extremity peripheral arterial disease, renal arterial lesions) [3]. The polymorbidity of atherosclerotic lesions is another problem as there is a high probability of developing uncorrectable arterial hypertension, diabetes mellitus, and metabolic syndrome [1]. All these factors indicate that patients with atherosclerotic ICA stenosis are high-risk patients and require both complex preoperative and advanced intraoperative monitoring.

Despite the considerable number of research works dealing with the analysis of methods of anaesthesia and intraoperative monitoring of cerebral blood flow the final conclusion of the advantages of one of these methods has not drawn yet [5]. Therefore, the question about the choice of a particular anaesthetic technique and intraoperative monitoring of cerebral blood flow during CEA remains open and deserves further study.

The objective of the research was to analyze the methods of intraoperative monitoring and the type of anaesthesia during carotid endarterectomy and to study their impact on the results of surgical treatment.

Materials and methods

Over the period 2011-2015 in clinic of vascular surgery at the Medical Faculty of VÚSCH (East Slovak Institute of Cardiovascular Diseases), Košice, Slovak Republic 415 patients with atherosclerotic lesions of carotid arteries were operated on. There were 266 men (64%) and 149 women (36%) at the age of 35-84 years. The average age of patients was 63.5±2.5 years (M±σ). There were 224 (54%) patients with symptomatic ICA stenosis and 191 (46%) patients with asymptomatic ICA stenosis.

The degree of ICA stenosis was measured using duplex ultrasonography (DUS**)** of the extracranial arteries. If stenosis of the deviations of aortic arch branches was suspected, pathological deformation of the ICA was present or there was a need to differentiate subtotal carotid artery stenosis from occlusion angiography was used.

CT angiography (CTA) of the brain was performed in patients with symptomatic ICA stenosis to detect ischemic foci.

If intracranial ischemic focus was not more than 2x3 cm in size and minimal neurological symptoms and signs were present (mild hemiparesis or monoparesis, hemiplegia) in patients with symptomatic ICA stenosis CEA was performed within the first 14 days after the development of ACD. If ischemic focus was more than 2x3 cm in size, or there were several ischemic foci CEA was performed 5-6 weeks after cerebrovascular accident.

Considering the etiology of atherosclerosis, a high probability of damage to two and more arterial blood pools and localization of atherosclerotic stenoses in carotid arteries in the preoperative period somatic (the evaluation of the functional state of the respiratory and cardiovascular systems) and neurological status of the patient were assessed. The main threat to

patients with atherosclerotic ICA stenosis is not neurological deficit and vertebrobasilar insufficiency but potential development of severe complications such as myocardial infarction (MI), acute cerebrovascular disease, and cerebral hyperperfusion syndrome in the postoperative period. Therefore, the evaluation of the stage of IHD, functional status of intracranial vessels and their reserve in the preoperative period is of great importance.

Preoperative anaesthetic assessment was performed the day before surgery after all preoperative examinations. During the examination particular attention was paid to major risk factors (Table 1).

Table 1

Major risk factors in examined patients

Somatic	IHD, previous MI, uncorrectable arterial hypertension, diabetes mellitus, COPD, age, obesity, smoking
Neurological	The level and degree of the neurological deficit, recurrent transient ischemic attacks (TIA), previous stroke, the degree of manifestation of chronic cerebral insufficiency
Angiographic, sonographic	Contralateral ICA occlusion, soft highly embologenic atherosclerotic plaque

In all patients CEA was performed under general anaesthesia. Intraoperative monitoring consisted of the 3 lead ECG including the analysis of the dynamic changes in the ST-segments, pulse oximetry, capnography and invasive measurement of blood pressure (BP).

Cerebral blood flow was controlled measuring oxygen saturation with the use of INVOS 5100 (Somanetics Corp., USA).

Intraoperative pharmacologic protection of the brain from ischemia was carried out due to controlled hypertension. In case of a decrease in transcranial oxygen saturation by 25-30% CEA was performed using an intraoperative shunt.

There were performed the traditional carotid endarterectomy with subsequent placement of the synthetic graft and eversion carotid endarterectomy. Preventive dose of low-molecular-weight heparin was administered 12 hours before surgery.

To assess the results of the research all patients were divided into 3 groups:

- Group I included patients being at risk of developing somatic diseases;
- Group II included patients being at risk of developing neurological and symptomatic conditions;
- Group III comprised patients with neurologic impairment being at risk of developing somatic diseases (Table 2).

The 3 groups did not differ significantly in age and gender.

Table 2

Comparative characteristics of patients in groups

Characteristics	Group I n= 102	Group II n= 239	Group III n= 74
Asymptomatic ICA stenosis	102 (100%)	89 (37.2%)	-
Symptomatic ICA stenosis	-	150 (62.8%)	74 (100%)
Somatic anamnesis			
Hypertensive disease	67 (65.7%)	174 (72.8%)	62 (83.8%)
IHD	38 (37.3%)	118 (49.4%)	49 (66.2%)

Previous MI	8 (7.8%)	28 (11.7%)	12 (16.2%)
Diabetes mellitus	12 (11.8%)	37 (15.5%)	11 (14.7%)
COPD	9 (8.8%)	19 (7.9%)	6 (8.1%)
Kidney failure	-	4 (1.7%)	2 (2.7%)
Obesity	58 (56.9%)	143 (59.8%)	46 (60.8%)
Smoking	68 (66.7%)	168 (70.3%)	51 (68.9%)
Neurological anamnesis			
Vertebrobasilar insufficiency	-	26 (10.9%)	19 (25.7%)
Signs of neurological deficit after ACD	-	-	59 (79.7%)
Contralateral ICA stenosis		67 (28.0%)	42 (56.8%)
Contralateral ICA occlusion	-	18 (7.5%)	9 (12.2%)
Previous contralateral CEA	3 (2.9%)	15 (6.3%)	11 (14.9%)
Previous ACD (more than 6 months)	-	84 (35.1%)	29 (39.2%)

The data were processed using the software package Statistica 6.

Results

Group I included patients with asymptomatic ICA stenosis. 37.2% of patients of Group II suffered from asymptomatic ICA stenosis and 62.8% of patients suffered from symptomatic ICA stenosis. All patients of Group III suffered from symptomatic ICA stenosis. Among somatic diseases hypertensive disease, IHD, diabetes mellitus and obesity prevailed in all patients. Group I included patients being at minimal risk of developing somatic diseases. The risk of neurological complications sharply increased in Groups II and III. Group III included high-risk surgical patients in CEA (Table 1).

When analyzing the results of CEA it was found that due to intraoperative cerebral oximetry in 56 (13.5%) patients when compressing the common carotid artery (CCA) oxygen saturation levels were found to be decreased by 25-30%. In these patients, CEA was performed using an intraoperative shunt.

The need for intraoperative shunting sharply increased in Group III. In Group I intraoperative shunts were used in 8% of patients while in Group III they were used in 23% of patients.

The incidence of perioperative complications is presented in Table 3.

Table 3

Incidence of perioperative complications in patients of different groups

Complication	Group I	Group II	Group III
ACD	-	2.1%	4.1%
MI	-	0.8%	1.4%
Mortality	-	1.3%	2.7%
Overall mortality/ complication rate	-	4.2%	5.4%

Among patients of Group I perioperative complications were not observed.

In Group II 3 patients developed ischemic stroke and 4 patients developed TIA in the early postoperative period. Two patients died after recurrent ACD. Three patients developed myocardial infarction. One of these patients died.

In Group III ischemic stroke was detected in 3 patients and TIA was found in 2 patients of this Group. 1 patient developed myocardial infarction. Two patients died after recurrent ACD.

Thus, the level of perioperative ischemic complications in Group II was 2.1% while in Group III it was 4.1%. The overall mortality/complication rate was 3.9% (4.2% in Group II and 5.4% in Group III). The overall perioperative mortality rate was 1.2%.

Discussion

The results of CEA in patients with atherosclerotic ICA stenosis were analyzed. The highest rate of complications was observed in patients of Group III with neurological deficit being at high risk of developing somatic diseases.

CEA may be performed under regional or general anaesthesia [5]. The advantages of one or another method of anaesthesia have not been proven yet [1, 6].

The main advantage of regional anaesthesia during CEA is the simplicity of intraoperative monitoring of cerebral blood flow [1, 3].

The advantages of general anaesthesia include better monitoring of airways; the ability to control and manipulate carbon dioxide (CO_2) levels; the ability to control and modify BP if there is a need to increase cerebral blood flow in order to reduce the metabolic needs of the brain tissues [2, 7].

The main disadvantage of general anaesthesia is the difficulty in early diagnosing cerebral ischemia at the stage of the compression of the ICA [5]. However, intraoperative monitoring is primarily used for the control of cerebral blood flow [7]. There are several methods of the control of cerebral blood flow. We measured transcranial cerebral oxygen saturation using the INVOS 5100 (Somanetics Corp., USA). About 85-90% of patients had a well-developed collateral circulation and tolerated the compression of the CCA well. In the remaining 10%-15% of patients CEA had to be performed with the use of an intraoperative shunt [2, 7]. We used the intraoperative shunt when operating 13.5% of patients.

Conclusions

General anaesthesia during CEA with intraoperative measurement of transcranial cerebral oxygen saturation allows us to achieve good perioperative results (the overall mortality/complication rate is 3.9%). Careful preoperative preparation considering somatic and neurological risk factors decreases the likelihood of postoperative complications.

Prospects for further research

Prospects for further research include differential selection of patients with asymptomatic ICA stenosis for CEA considering biochemical markers of inflammation and morphological structure of atherosclerotic plaque.

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