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# Carotid Endarterectomy and Coronary Artery Disease

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**Auksė Meškauskienė,  
Virginija Gaigalaitė**

*Neurovascular Surgery Clinic of  
Vilnius University,  
Šiltanamių 29,  
LT-2043 Vilnius, Lithuania*

**Objectives.** Evaluate the significance of clinical coronary artery disease in the incidence of perioperative myocardial infarction, death and complications for the patients undergoing carotid endarterectomy and by routine noninvasive cardiac investigation to identify patients at high risk of adverse cardiac events.

**Methods.** This was a study of 328 patients who underwent carotid endarterectomy in Vilnius Emergency Hospital during a 6-year interval (1995–2000). These patients were evaluated for clinical and ECG symptoms of coronary artery disease and divided into two groups: with and without coronary artery disease. Both groups were compared according rate of complications and risk factors.

**Results.** There were 2 nonfatal (0.9%) and 1 (0.3%) fatal myocardial infarctions. On the basis of clinical evidence of coronary artery disease, the incidence of myocardial infarction was 1.96%. In the absence of angina pectoris, history of myocardial infarction, coronary bypass grafting, coronary angioplasty or asymptomatic Q wave on electrocardiogram, myocardial infarction mortality and morbidity was 0%. The total mortality rate was 2.4% (eight patients). In the group without coronary artery disease mortality rate was lower (1.7% versus 3.3%,  $p > 0.05$ ) and there were no adverse cardiac events. Stroke mortality rate was higher (2.6% versus 1.7%,  $p > 0.05$ ) in the group with coronary artery disease. The total operative mortality and complication rate did not significantly differ between the groups with coronary artery disease and without it (6.5% versus 4%,  $p > 0.05$ ). Angina pectoris was a risk factor for perioperative myocardial infarction ( $p < 0.001$ ). Asymptomatic coronary artery disease had a better prognosis for operative complications than symptomatic CAD ( $p < 0.005$ ).

**Conclusions.** The prevalence of coronary artery disease in carotid surgery patients exerts an effect on the perioperative myocardial infarction rate. Patients with asymptomatic disease had a better operative prognosis than patients with clinical symptoms present. The routine preoperative noninvasive cardiac investigation is adequate to identify patients at high risk for coronary events. Knowledge of the presence of coronary artery disease might influence operative intervention related to the degree of perioperative monitoring and the choice of medical therapy. The challenge for the future is to make the perioperative risk as low as possible.

**Key words:** carotid endarterectomy, coronary artery disease, complications, myocardial infarction, risk factors

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## INTRODUCTION

In well-known studies of North American (NASCET) and European Symptomatic Carotid Endarterectomies (ECST) the patients who died of medical complications in the perioperative period mostly died from cardiac causes (1,2). Coronary artery disease (CAD) has a high prevalence in patients undergoing carotid endarterectomy (CE) and strongly influences their perioperative course and long-term follow-up (3, 4). Myocardial infarction is one of the most common causes of death after carotid endarterectomy

(CE) (5). The risk of myocardial infarction after CE in symptomatic patients has been reported but varies in different settings from 1.8% to 3.9% (6, 7). Fatal perioperative myocardial infarction varies in incidence from 0.75% to 1.7% (8–10). Myocardial infarction being one of the most common causes of death after CE, preoperative cardiac evaluation, through clinical assessment or numerous qualitative and quantitative testing techniques, has been extensively studied (11). Clinical evaluation has been used by numerous authors to identify constellations of risk factors that appear to place patients at high risk for

adverse cardiac events after this surgical procedure (12). On the basis of clinical evaluation and strict cardiac exclusion criteria, the NASCET minimized the risk of myocardial infarction (13). In light of the low perioperative cardiac mortality and morbidity rates achieved after a careful clinical evaluation and selection of patients for operative intervention, the exact role of extensive preoperative cardiac evaluation has been questioned (12).

**Purpose.** To determine the incidence of myocardial infarction, fatal myocardial infarction and overall mortality rates among patients undergoing carotid endarterectomy and to identify, by routine preoperative noninvasive cardiac investigation, patients at high risk of adverse cardiac events.

## SUBJECTS AND METHODS

All 328 patients that underwent carotid endarterectomy at Vilnius University Emergency Hospital from 1995 to 2000 were included in this study. The baseline evaluation consisted of a detailed medical history, complete physical, cardiological, neurological examination and an electrocardiogram (ECG). Patients were considered to have no history of CAD if they did not have a history of coronary artery bypass grafting (CABG) or percutaneous angioplasty (PTA), angina pectoris, symptomatic MI or evidence of an asymptomatic MI (Q waves) by ECG. Thus, all patients were divided into two groups: patients with a history of CAD and without CAD. Detailed information on the following clinical and angiographic features was obtained on all patients: age, sex, arterial hypertension, diabetes mellitus, cigarette smoking, obesity, peripheral vascular disease (history of claudication or arterial reconstructive surgery), lipoproteinogram, hematocrit, fibrinogen, neurologic status, brain CT. The angiographic method of measurement was that of NASCET, i.e., consisted in comparing the greatest degree of linear diameter stenosis of the internal carotid artery at the carotid bifurcation to the diameter of the distal normal internal carotid artery. We excluded patients who had more severe stenosis of distal than of the proximal carotid artery. All patients had carotid stenosis of at least 50% of the diameter, demonstrated by duplex scanning and angiography. Indications for CE included symptoms of TIA or stroke ipsilateral to the side of the operation in 58% of patients and 42% for patients with asymptomatic carotid stenosis (nonhemispheric 22%, symptom-free 10% and with symptoms of cerebral or retinal ischemia referable to the contralateral carotid artery-10%). The operated lesion was more than 90% stenotic in 56% of patients. Under general endotracheal anesthesia were operated 313 patients and under regional cervical

plexus block anesthesia with lidocaine 15 patients. The median anesthetic time was 3 hours and surgical time 2 hours. The monitoring for cerebral ischemia during carotid clamping was monitored using a transcranial doppler device for the patients under general anaesthesia, while under regional anaesthesia mental status evaluation was used. In cases of a decrease of cerebral blood flow by 50% or more, a Javid shunt was placed. Indwelling shunts were used in 57% of the operations.

Patients were followed for the development of complications during their hospital course. A primary outcome was the development of cardiac complications, specifically myocardial infarction (based on clinical, ECG and serum troponin test), angina pectoris, congestive heart failure and atrial fibrillation. The secondary outcome was postoperative stroke, defined as the onset of a new neurological deficit (unrelated to cranial nerve injury), lasting >24 hours and causing permanent disability or death during hospital course. Adverse cardiac event rates and vascular risk factors were compared in patients with CAD versus patients without CAD.

**Statistical analysis.** For statistical analysis, Fisher's exact test and X test were used. The level of significance was set at  $p < 0.05$ . NS denotes a  $p$  value  $> 0.05$ .

## RESULTS

During the 6-year interval (1995–2000), 328 carotid endarterectomies were performed at the department of vascular surgery of the Vilnius University Emergency Hospital. The mean age of the patients was 62 years (range, 38 to 95 years). Forty one patient (12%) were older than 75 years. There were 257 men (78%) and 71 women (22%). Risk factors for atherosclerosis were tabulated for all 328 patients (Table 1). Hypertension presented in 65%, tobacco usage in 58%, hypercholesterolemia in 48%,

Table 1. Vascular risk factors in carotid endarterectomy patients

Variables	Patients	%
1. Age >75 years	71	22
<75 years	257	78
2. Sex men	257	78
women	71	22
3. Hypertension	207	63
4. Current smoker	192	58
5. Hypercholesterolemia	157	48
6. Diabetes mellitus	43	12
7. Obesity	64	20
8. Peripheral atherosclerosis	41	12

**Table 2. Clinical and ECG findings of coronary artery disease in 153 carotid endarterectomy patients**

	N	%
1. Angina pectoris	33	21
2. Angina pectoris and MI in history	79	52
3. Asymptomatic Q waves on ECG	20	13
4. CABG or PTA	21	14

CABG – coronary artery bypass grafting; PTA – percutaneous transluminal angioplasty.

obesity in 20%, diabetes mellitus and peripheral atherosclerosis in 12% patients. Coronary artery disease was present in 153 (47%) patients. Among them, 79 (52%) had angina pectoris with a history of MI (myocardial reinfarction in 25 patients), 33 (21%) had extension and the rest had angina pectoris without previous MI, 20 (13%) were asymptomatic for CAD with Q waves on ECG, 21 (14%) had undergone CABG or PTA (Table 2). Eleven patients had atrial fibrillation and six patients had clinical signs of congestive heart failure.

**Table 3. Complications of carotid endarterectomy in patients with versus without CAD**

Complication	All patients n = 328	Patients with CAD n = 153	Patients without CAD n = 175	p
Death	8 (2.4%)	5 (3.3%)	3 (1.7%)	0.29
Stroke	7 (2.1%)	4 (2.6%)	3 (1.7%)	0.90
Myocardial infarction	1 (0.3%)	1 (0.6%)	0	0.25
Stroke	6 (1.8%)	3 (1.9%)	3 (1.7%)	0.78
Myocardial infarction	2 (0.6%)	2 (1.3%)	0	0.56
Total	16 (4.8%)	10 (6.5%)	6 (3.4%)	0.74

**Table 4. Baseline characteristics and risk of complications in carotid endarterectomy patients without versus with coronary artery disease**

Clinical variable	Without CAD				With CAD				p
	patients n = 175		complications n = 6		patients n = 153		complications n = 10		
1. Age >75 years	34	19%	0	0%	37	24%	2	20%	NS
<75 years	141	81%	6	100%	116	76%	4	80%	NS
2. Men	136	79%	5	83%	121	79%	3	70%	NS
3. Women	39	21%	1	17%	32	21%	3	30%	NS
4. Smokers	107	61%	3	50%	85	55%	5	50%	NS
Nonsmokers	69	39%	3	50%	68	45%	5	50%	NS
5. Hypertension	107	61%	5	83%	100	70%	8	80%	NS
No	68	39%	1	17%	53	30%	2	20%	NS
6. Diabetes	25	14%	2	33%	18	12%	3	30%	NS
No	150	86%	4	67%	135	88%	7	70%	NS
7. Peripheral atheroscl	23	13%	0	0%	18	12%	2	20%	NS
No	152	87%	6	100%	135	88%	8	80%	NS
8. Obesity	23	13%	4	67%	41	27%	3	30%	0.002
No	152	87%	2	33%	112	73%	7	70%	NS
9. Cholesterol ≥5.5 mmol/l	91	66%	4	80%	71	63%	6	75%	NS
<5.5 mmol/l	46	40%	1	20%	42	37%	2	25%	NS
10. HDL ≥0.93 mmol/l	94	81%	1	33%	63	69%	1	17%	0.049
<0.93 mmol/l	22	19%	2	67%	28	31%	5	83%	NS
11. LDL ≥3.0 mmol/l	98	80%	2	100%	61	81%	4	80%	NS
<3.0 mmol/l	24	20%	0	0%	14	19%	1	20%	NS
12. TAG ≥2.0 mmol/l	37	30%	0	0%	24	26%	2	50%	NS
<2.0 mmol/l	84	70%	5	100%	67	74%	2	50%	NS
13. Fibrinogen ≥4.0 g/l	90	55%	3	50%	76	57%	5	50%	NS
<4.0 g/l	72	45%	3	50%	57	43%	5	50%	NS

Table 5. Neurological and angiographical findings and risk complication in carotid endarterectomy patients without versus with CAD

Clinical variable	Without CAD				With CAD				p
	patients n = 175		complications n = 6		patients n = 153		complications n = 10		
1. Stroke or TIA	69	39%	2	33%	84	55%	5	50%	NS
Nonhemispheric	106	61%	4	67%	69	45%	5	50%	NS
2. Hypodensity KT	67	67%	3	100%	67	67%	1	20%	NS
No	33	33%	0	0%	33	33%	4	80%	NS
3. Ipsilateral stenosis ≥90	95	54%	3	50%	88	57%	8	80%	NS
<90	80	46%	3	50%	65	43%	2	20%	NS
4. Contralateral stenosis ≥70	25	14%	2	33%	28	18%	2	20%	NS
<70	150	86%	4	67%	125	82%	8	80%	NS
5. Contralateral occlusion	30	17%	0	0%	24	16%	4	40%	NS
No occlusion	145	83%	6	100%	129	84%	6	60%	NS

Table 6. Clinical, ECG findings of CAD and complication rate in patients with CAD undergoing carotid endarterectomy

Clinical features	Patients	%	Complications	%
1. Angina pectoris	33/153	22%	10/10	100%
2. Myocardial infarction in history	79/153	52%	10/10	100%
3. Q on ECG	20/153	13%	0/10	0%
4. CABG or PTA	21/153	4%	0/10	0%
5. Heart failure	11/153	7%	2/10	20%
6. Atrial fibrillation	6/153	4%	0/10	0%

In this series of 328 patients, the perioperative fatal myocardial infarction rate was 0.3% (one patient) and nonfatal myocardial infarction 0.6% (two patients), the overall myocardial infarction morbidity being 0.9%. After endarterectomy, two patients with repeated MI in the history had congestive heart failure and one patient had atrial fibrillation. The overall mortality rate was 2.4% (eight patients): seven (2.1%) patients died from stroke and one from myocardial infarction (0.3%), accounting for 12.5% of all deaths (Table 3). A new disabling neurological deficit developed in four patients (2.1%). The combined stroke mortality rate was 3.65%.

For a number of baseline variables, there was no association with either increased or decreased complication rate. These included the age and sex of a patient, a history of hypertension, smoking, diabetes, hyperlipidemia, whether or not a stroke or TIA had occurred before the CE or whether the stenosis was > 90%.

In the 175 patients who did not exhibit any of the common characteristics of CAD, there were no incidence of myocardial infarction and any adverse cardiac event. All myocardial infarctions occurred in patients with symptoms of CAD. The group of patients with CAD had a lower HDL ( $p < 0.049$ ) and

were more obese ( $p < 0.002$ ), meanwhile other risk factors in these two groups were not statistically distinct (Table 4). The neurological and angiographic findings did not differ significantly in patients with versus without CAD (Table 5). CAD was associated with an increased risk of perioperative stroke and death, but it failed to reach statistical significance. Clinical and

ECG symptoms of CAD were examined for association with perioperative myocardial infarction and death (Table 6). Angina pectoris had a bad prognostic value ( $p < 0.001$ ). Asymptomatic patients (Q waves on ECG) were not in danger for cardiac complications. One baseline variable was unexpectedly associated with a reduced risk of operative MI. Twenty one patients with the history of CAD who had a prior cardiac procedure (CABG or PTA) and were symptom-free had no adverse cardiac events after their carotid operation.

## DISCUSSION

Carotid endarterectomy may cause complications either by the operation itself or by concomitant medical conditions. The risk in the postoperative period of complications was higher in patients who had CE than in medically treated patients within the same period (14). These comparisons suggest that most of the complications were triggered by the procedure. On the other hand, the prevalence of coexisting coronary lesions in candidates for carotid endarterectomy is high. Even among those without history of CAD, coronary angiography disclosed lesions in 86% of patients, and they were significant in 40%

(15). Therefore patients undergoing carotid endarterectomy are at high short- and long-term risk for coronary events. In an earlier report of a series collected between 1967–1973 from Cleveland Clinic, the early mortality rate after carotid operation was 9.6% in patients with a history of coronary artery disease *versus* only a 2.9% risk in patients with no clinical evidence of coronary artery disease (5). Wong et al. (16) reported 8.9% of complications of angina, myocardial infarction, congestive heart failure or dysrhythmia in 291 patients operated on.

In our study, in patients that underwent carotid endarterectomy the overall mortality rate was 3.6% and was within the guidelines recommended by the American Heart Association for institutions and surgeons performing carotid endarterectomy (17). In NASCET, the combined stroke mortality rate was 2.7%. The ECST, similar in size to NASCET, has reported results with comparable rates of perioperative complications (2.8%). Individual institutions have reported similar results (18). The results from our institution did not differ from those reported in multicenter international studies, as well as from the results achieved at individual institutions in the community and university settings (19–22). A recent study from 10 academic medical centers for the period 1990–1995 by Holloway et al. (23) found an in-hospital mortality rate of only 0.5% for CE.

Adverse cardiac events in our series of patients occurred after 6 of 328 operative procedures. The myocardial infarction rate was 0.6% and the fatal myocardial infarction rate was 0.3%. The low rate of myocardial infarction in our series and those reported by others (6, 7, 14, 19, 23, 25) does not deny the necessity of a careful clinical evaluation and the exact role of preoperative cardiac evaluation. We therefore looked at clinical factors in this group of 328 patients to determine patients with CAD (Q waves, previous MI, angina, history of CAGB or PTA) and patients without CAD. In the 175 patients who did not exhibit any common characteristics of CAD there were **no incidence** of myocardial infarction. In the 153 patients with coronary artery disease the incidence of myocardial infarction was 1.96%. In fact, angina pectoris with or without previous MI has been suggestive and predictive. Eagle et al. (24) identified five clinical risk factors for coronary artery disease (Q waves, history of congestive heart failure, diabetes, age >70 and angina pectoris) and reported an increased number of adverse cardiac events in patients with these factors present.

In our series these simple, easily obtainable clinical characteristics allowed definition of the subset of patients at increased risk for adverse coronary events after carotid operation. Our data are in sup-

port of the fact that a routine preoperative noninvasive cardiac investigation is generally adequate to identify patients at high risk for coronary events (25). The preoperative investigation must include a careful history taking with a particular emphasis on previous myocardial infarction, past or persisting angina, decreased exercise tolerance, other evidences of past or persisting congestive failure and history or persistence of rhythm disorder. ECG and chest radiography to ascertain heart size should be routine (26). A transthoracic and, when indicated, a transeosophagal echocardiogram, a stress test and rhythm monitoring should be obtained in doubtful cases. As documented by Urbinati et al. (25), however, the long-term survival after carotid operation appears to be significantly affected by abnormal results of a cardiac evaluation study. Our data do not address the long-term results of carotid operation. The results from our study agree with those published by Taylor et al. (12), indicating that intensive cardiac evaluation and intervention cannot be justified in light of the low operative mortality rate achieved with most vascular reconstructive procedures in patients who do not demonstrate significant clinical risk factors.

The incidence of silent CAD, 25% as reported by S. Urbinati et al. (25), would indicate that the short-term results of perioperative mortality in our study were not affected adversely. We had not adverse cardiac events in the group of patients with asymptomatic CAD. Patients who had had coronary bypass grafting or percutaneous transluminal coronary angioplasty remained symptom-free and no complications occurred.

Since CE is a relatively common vascular procedure, internists, surgeons and anesthesiologists must strive to reduce the incidence of postoperative complications to an absolute minimum. Special attention to risk factors, detailed preoperative cardiac investigations, careful operative monitoring can reduce complications in high-risk patients. The results of this study suggest that a clinical evaluation by the cardiologist appears to be effective, because patients with asymptomatic CAD or without CAD are at a low risk for cardiac events.

## CONCLUSIONS

The prevalence of coronary artery disease in carotid surgery patients exerts an effect on the perioperative myocardial infarction rate. Patients with asymptomatic CAD had a better operative prognosis than patients with clinical symptoms of CAD. The routine preoperative noninvasive cardiac investigation is adequate to identify patients at high risk for coronary events. Knowledge of the presence of coronary

artery disease might influence operative intervention related to the degree of perioperative monitoring and the choice of medical therapy. The challenge for the future is to make the perioperative risk as low as possible.

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**Auksė Meškauskienė, Virginija Gaigalaitė**

## MIEGO ARTERIJOS ENDARTEREKTOMIJA IR KORONARINĖ ŠIRDIES LIGA

S a n t r a u k a

**Darbo tikslas** buvo nustatyti miokardo infarkto dažnį, mirčių dėl miokardo infarkto, bendrą mirčių bei komplikacijų skaičių ligoniams, kuriems buvo atlikta vidinės miego arterijos endarterektomija ir kasdieninių neinvazinių tyrimų pagalba iki operacijos išaiškinti didelės rizikos ligonius.

**Metodai ir medžiaga.** Tai buvo studija 328 vidinės miego arterijos endarterektomijų, atliktų 1995–2000 metais Vilniaus greitosios pagalbos universitetinėje ligoninėje. Ligoniai pagal koronarinės širdies ligos klinikinius ir EKG požymius suskirstyti į dvi grupes: su KŠL ir be. Lygintos grupių operacinės komplikacijos ir komplikacijų rizikos veiksniai.

**Rezultatai.** Pooperaciniu miokardo infarktu sirgo trys (1,2%) ligoniai, iš jų vienas mirė (0,3%). Grupėje su klinikiniais koronarinės širdies ligos simptomais miokardo infarktu sirgo 1,96% ligonių, o grupėje be koronarinės ligos požymių (nėra Q dantelio EKG, miokardo infarkto anamnezėje, krūtinės anginos ar širdies nepakankamumo simptomų) pooperaciniu miokardo infarktu nebuvo. Iš viso po vidinės miego arterijos endarterektomijos mirė aštuoni ligoniai (2,4%). Grupėje su KŠL mirčių buvo daugiau (3,3% prieš 1,7%,  $p > 0,05$ ). Mirčių skaičius dėl pooperacinio insulto tarp ligonių su koronarine širdies li-

ga buvo didesnis (2,6% prieš 1,7%,  $p > 0,05$ ), lyginant su grupe be KŠL. Bendras mirčių ir komplikacijų skaičius tarp grupių su koronarine širdies liga ir be jos buvo 6,5% prieš 4,0%,  $p > 0,05$ . Vienintelis operacinio MI rizikos veiksnys buvo krūtinės angina ( $p < 0,001$ ). Besimptomės KŠL operacijos prognozė buvo geresnė nei simptominės KŠL ( $p < 0,005$ ).

**Išvados.** Ligoniai su ryškiais koronarinės širdies ligos simptomais turi didesnę riziką sirgti operaciniu miokardo infarktu. Besimptomės KŠL operacijos prognozė geresnė nei turintiems KŠL simptomus. Klinikinio koronarinės ligos nustatymo pakanka, kad ligonis būtų priskirtas aukštos rizikos grupei ir todėl keičiama operacinė stebėseną bei gydymas. Ateities uždavinys – sumažinti iki minimumo pooperacinių miokardo infarktų skaičių.

**Raktažodžiai:** miego arterijos endarterektomija, koronarinė širdies liga, komplikacijos, miokardo infarktas, rizikos veiksniai