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Carotid artery stenting outcomes in high-risk patients receiving best medical therapy: results from a single high-volume interventional cardiology practice

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SOUHRN

Kontext: Implantace stentů do karotických tepen (carotid artery stenting, CAS) se v současnosti ve velkém měřítku používá v léčbě stenózy karotických tepen. Klinické studie z poslední doby prokázaly nízkou incidenci příhod po CAS. Tato studie hodnotí 30denní a roční výsledky pacientů léčených pro CAS intenzivní farmakoterapií na pracovišti provádějícím vysoké počty perkutánních koronárních intervencí ročně.

Metoda: V období od ledna 2011 do prosince 2013 byla CAS provedena celkem u 184 pacientů. Mimo protidestičkové léčby byla prováděna i intenzivní antihypertenzní léčba spolu s vysoce intenzivní terapií statiny a léčbou zaměřenou na normalizaci srdeční frekvence. Pacienti byli stratifikováni podle věku a symptomů.

Výsledky: Většina pacientů (86,4 %) splňovala alespoň jedno kritérium vysokého operačního rizika. Výkon byl úspěšný v 98,4 % případů. Třicetidenní a roční incidence cévních mozkových příhod (CMP) byla 4,1 %, resp. 4,5 %. Po 30 dnech byla kombinovaná incidence CMP/úmrtí z kardiovaskulárních (KV) příčin/infarktu myokardu (IM) 5,8 %; po jednom roce dosáhla hodnoty 10,9 %. Třicetidenní incidence CMP/úmrtí z KV příčin u asymptomatických a symptomatických pacientů byla 5,4 %, resp. 4,2 %. Věk ≥ 80 let zvyšoval riziko vzniku CMP/úmrtí z KV příčin/IM do jednoho roku (OR 4,41; 95% CI 1,06–18,36; *p* = 0,04).

Závěry: Studie prokázala přijatelné klinické výsledky pacientů s CAS a vysokou incidencí přidružených onemocnění, kteří byli léčeni intenzivní farmakoterapií. Incidence příhod u symptomatických pacientů nepřesáhla rozmezí uváděné v guidelines jako doporučené, zatímco u asymptomatických pacientů byla incidence zvýšená.

ABSTRACT

Background: Carotid artery stenting (CAS) is now being widely used in the treatment of carotid artery stenosis. Recent clinical studies have demonstrated low adverse event rates after CAS. This study evaluates the 30-day and 1-year results in patients treated with CAS and receiving intensive medical therapy in a high-volume percutaneous coronary intervention centre.

Methods: A total of 184 patients underwent CAS between January 2011 and December 2013. In addition to antiplatelet therapy, patients received intensive antihypertensive treatment, high intensity statin and heart rate normalization therapy. Patients were stratified according to age and symptomatic status.
Results: Most of the patients (86.4%) had at least one high surgical risk criteria. The procedural success rate was 98.4%. The 30-day and 1-year incidence of stroke was 4.1% and 4.5%. At 30 days the combined rate of stroke/cardiovascular (CV) death/myocardial infarction (MI) was 5.8% and 10.9% in 1 year. The 30-day incidence of stroke/CV death in asymptomatic and symptomatic patients was 5.4% and 4.2%. Age ≥80 years increased the risk of stroke/CV death/MI at 1 year (OR 4.41; 95% CI 1.06–18.36; $p = 0.04$).
Conclusions: The study demonstrated acceptable clinical outcome results in patients with high medical co-morbidities treated with CAS and intensive medical therapy. Adverse event rate in symptomatic patients did not exceed the guideline recommended range while in asymptomatic patients it was increased.

Introduction

Coronary artery disease is commonly associated with lesions in other vascular beds, including carotid arteries. More than half of patients with three vessel and/or left main coronary artery disease (CAD) have at least some degree of atherosclerotic carotid disease, while 7–11% of these patients have severe carotid artery stenosis (CAS) potentially mandating intervention [1]. Carotid artery stenosis frequently is newly diagnosed at the time of coronary angiography. Due to the high experience in the management of coronary atherosclerosis, a significant proportion of stenotic lesions in the carotids are now being treated by interventional cardiologists.

Low incidence of adverse events after stenting has been shown in several single and multicenter clinical practice studies [2–6]. One of the latest trials to date, Carotid Revascularization Endarterectomy vs. Stenting Trial (CREST) demonstrated comparable outcome rates after stenting and surgery. However, an interaction between age and treatment efficacy was detected with a crossover at an age of approximately 70 years [7]. Increasing risk for stroke after CAS was shown at older ages [8].

The objectives of this study were to evaluate the clinical outcomes and to analyze the impact of age in patients undergoing CAS in the background of intensive medical therapy.

Methods

A total of 184 patients underwent CAS from January 2011 to December 2013 and were enrolled in a prospective registry. The procedures were performed in a University Hospital Percutaneous Coronary Intervention (PCI) Centre with approximately 4 000 PCI procedures per year. All CAS procedures were performed by high-volume PCI interventional cardiologists with an experience level of more than 20 CAS procedures per year.

Patients were referred by their primary care physician or cardiologist after the diagnosis of carotid artery stenosis during a regular check-up, before coronary artery bypass grafting or valve surgery or after a stroke or transient ischemic attack (TIA). The stenosis was evaluated by duplex ultrasound, CT or invasive angiography. All patients underwent at least one CAS procedure. Patients with bilateral stenosis had revascularisation at two stages.

The study was approved by an institutional review committee. All patients gave an informed consent. Patients were eligible for the study if the internal carotid artery diameter stenosis was ≥50% for symptomatic and ≥75% for asymptomatic patients confirmed by invasive angiography. The cut-off values were selected according to the inclusion criteria in randomized clinical trials and local revascularization practice. The exclusion criteria were allergy to antiplatelet therapy, recent gastric bleeding and/or hemorrhagic stroke.

All patients continued aspirin (75–100 mg/day) therapy and received clopidogrel loading dose 300 mg at least 24 h prior to CAS. During CAS, patients were anticoagulated with unfractionated heparin (100 U/kg). GPIIb/IIIa receptor antagonist administration was left to the discretion of the operator. Atropine was used before or during the procedure to prevent bradycardia. If severe hypotension developed during the procedure, dopamine or epinephrine infusion was initiated.

Unless otherwise indicated, dual antiplatelet therapy with aspirin (75–100 mg/day) and clopidogrel (75 mg/day) was prescribed for at least six months after CAS and aspirin continued lifelong. Patients with atrial fibrillation at least six months post procedure received triple therapy with aspirin, clopidogrel and warfarin. Moderate intensity (20 mg atorvastatin or 10 mg rosuvastatin) or high intensity (40–80 mg atorvastatin or 20–40 mg rosuvastatin) statin therapy was prescribed lifelong for all patients. Antihypertensive therapy with the target blood pressure below 140/90 mmHg (or systolic blood pressure less than 130 mmHg in patients with diabetes) was prescribed for all hypertensive patients. Beta-blockers and/or ivabradine therapy was prescribed for heart rate normalization (60–70 beats per minute in patients with sinus rhythm).

Carotid arteries were accessed using a femoral approach with 6F introducer sheath or 8F, 9F or 10F guiding catheters. Embolic protection devices – distal embolic filters or MoMa (Invatech, Roncadelle, Italy) proximal cerebral protection device were used in all procedures. Predilatation was performed in patients with severe (≥90%) calcified stenosis if the stent could not be delivered through the stenotic lesion. Six types of stents were used, followed by a balloon catheter postdilatation.

Patients were defined symptomatic if they suffered a stroke or a TIA within the previous 180 days. Procedural success was defined as a successful stent placement with a residual stenosis of less than 30%. Patients were considered at high risk for CEA if they had at least one of the following criteria: age of ≥80 years; congestive heart failure NYHA III–IV; left main and/or ≥2 vessel coronary arte-

ry disease (CAD); urgent cardiac surgery in the preceding 30 days; MI within 30 days; contralateral carotid artery occlusion. Patients with any neurological symptoms after CAS were assessed by a neurologist. Any focal neurological deficit associated with stenosis lasting no longer than 24 h was defined as TIA. Any mild symptoms (minor stroke) or severe neurological symptoms (major stroke) persisting longer than 24 h were defined as stroke. Myocardial infarction was defined as elevation of cardiac biomarkers together with evidence of myocardial ischemia and with ECG changes indicative of new ischemia or development of pathological Q waves in the ECG. Vascular complications were defined as bleeding at the access site or any other bleeding that required a blood transfusion. Worsening renal function was defined as an elevation in the serum creatinine post procedure.

Stroke, MI and cardiovascular (CV) death were analyzed 30 days and one year after stenting in the study population and in patients stratified by age <70 and ≥70 years. Stroke/CV death was analyzed in patients according to symptom status. Two patients were referred to CEA after the failure in gaining carotid access and were excluded from the clinical outcome analysis. The clinical follow-up included data about any cerebrovascular accidents, MI, death and other revascularization procedures (PCI, CEA, CABG) after the initial CAS. Follow-up information was not collected from 10 (5.5%) patients. In-hospital outcomes were analysed in all study patients that underwent CAS (N = 182), the 30-day and 1-year results in 172 patients, excluding the patients that were lost to follow-up. Mortality rates were analyzed in all patients, after confirming the status of the missing patients using a national registry.

Table 1 – Baseline characteristics.				
			Age, years	
Characteristic	Total (N = 184)	<70 (N = 91)	≥70 (N = 93)	p value
Age, mean ± SD	69.1 ± 9.0	61.7 ± 5.7	76.4 ± 4.7	0.03
Male sex, %	73.9	80.2	66.7	0.03
Risk factors				
Hypertension, %	79.2	78.6	80.7	0.85
Current smoking, %	72.3	78.7	65.8	0.11
Diabetes, %	22.5	23.8	20.2	0.58
Dyslipidemia, %	76.9	83.3	82.2	0.99
Carotid artery disease				
Asymptomatic, %	72.0	73.6	70.3	0.87
History of stroke/TIA, %	13.7	13.2	14.3	0.87
Symptomatic, %	14.3	13.2	15.4	0.87
Previous CEA, %	1.7	2.3	1.2	0.51
Coronary artery disease, %	91.7	93.3	90.2	0.59
Previous MI, %	31.7	42.4	32.1	0.20
Previous PCI, %	54.8	64.3	44.6	0.01
Previous CABG, %	13.1	14.3	12.1	0.82
Peripheral artery disease, %	34.9	40.7	28.6	0.11
Congestive heart failure, %	64.1	65.9	61.9	0.63
Structural valve disease, %	20.6	15.0	25.3	0.12
Previous valve surgery, %	3.0	1.2	4.8	0.22
Atrial fibrillation, %	15.6	14.1	17.3	0.67
Chronic kidney disease, %	11.5	6.0	17.5	0.03
High surgical risk, %	86.4	87.9	85.0	0.67
Age ≥80 years, %	12.0			
CHF NYHA III–IV, %	18.7	11.1	26.4	0.04
Left main and/or ≥2 vessel CAD, %	79.6	85.4	73.9	0.07
Urgent cardiac surgery, %	3.3	3.3	3.2	0.99
MI within 30 days, %	5.0	6.2	3.8	0.72
Contralateral carotid artery occlusion, %	9.1	12.8	6.1	0.29

CABG – coronary artery bypass grafting; CAD – coronary artery disease; CEA – carotid endarterectomy; CHF – congestive heart failure; MI – myocardial infarction; PCI – percutaneous coronary intervention; SD – standard deviation; TIA – transitory ischemic attack.

Continuous variables were expressed as mean ± standard deviation (SD). Categorical variables were expressed as percentages and frequencies. Fisher's exact test was used to assess the differences between groups with categorical variables. Results with $p < 0.05$ were considered statistically significant. Univariate logistic regression analysis was performed to examine the predictors associated with 1 year risk of stroke/CV death/MI. Variables showing a tendency ($p < 0.20$) of association with elevated 1-year risk of stroke/CV death/MI in the univariate analysis were inserted in the multivariate analysis to assess the independent predictors of adverse events at 1-year follow-up.

All statistical analysis was performed using PSPP 0.8.2 software.

Results

Patient baseline characteristics are shown in Table 1. A total of 14.3% patients were symptomatic. Concomitant CAD was observed in 91.7% patients and 79.6% had multivessel and/or left main CAD. Most of the patients (86.4%) were considered at high surgical risk. Congestive heart failure (CHF) was present in 64.1% of patients. A higher prevalence of CHF NYHA III–IV was observed in patients aged ≥70 years ($p = 0.04$). Six patients (3.3%) underwent CAS before coronary artery bypass grafting or valve surgery. CHF NYHA III–IV ($p = 0.04$) and chronic kidney disease ($p = 0.03$) was more prevalent in patients aged ≥70 years. No significant differences were observed in the baseline characteristics in symptomatic and asymptomatic patients.

The procedural characteristics are shown in Table 2. Procedural success was not obtained in two patients with the third type aortic arch due to the problematic vascular access. They were referred to CEA. A stent was not implanted in a patient with a severely calcified lesion in the right internal carotid artery. An embolic protection device was used in all of the procedures. Distal protection filters were used in 76.3% and proximal protection MoMa device in 23.7% of procedures. High intensity statin therapy was prescribed for 87.8% of patients. The procedural characteristics and medical treatment did not differ in patients stratified by age <70 or ≥70 years and symptom status.

The post-procedural outcomes are shown in Table 3. A patient died during the hospital stay six hours after a successful CAS from an acute heart failure with a severe pulmonary edema. The patient was polymorbid and had a critical aortic valve stenosis, congestive heart failure NYHA II, diabetes and peripheral artery disease. Three patients suffered a stroke in hospital. Among them, one patient underwent aortic valve implantation surgery one day after CAS and suffered a non-ipsilateral stroke in the third day post procedure. None of the clinical outcomes showed significant differences according to age of <70 or ≥70 years. Although the group of octogenarians was small (20 patients), higher 1-year CV mortality and stroke/CV death/MI rates were observed amongst octogenarians. The risk of stroke within 30 days in the octogenarian group tended to be higher, although not reaching statistical significance. No differences in any of the major adverse events were

Table 2 – Procedural characteristics.	
Characteristic	**Total**
Left internal carotid artery, %	50.0
Right internal carotid artery, %	50.0
Procedural success, %	98.4
Guiding catheter	
6F, %	13.1
8F, %	76.6
9F, %	9.2
10F, %	1.1
Predilatation, %	7.6
Embolic protection, %	100.0
FilterWire EZ, %	43.5
Spider, %	19.8
Emboshield, %	13.0
MoMa device, %	23.7
Stent	
Exact, %	54.5
Wallstent, %	2.2
Adapt, %	33.3
Cristallo, %	6.7
Acculink, %	2.2
NextStent, %	1.1
Stent length, mean (mm) ± SD	35.6 ± 5.7
Stent diameter, mean (mm) ± SD	8.9 ± 0.75
Postdilatation, %	94.9
DAPT at least 24 h before CAS, %	92.6
During procedure	
GPIIb/IIIa inhibitors, %	59.1
Vasopressors, %	5.7
Atropine, %	48.6
DAPT at least six months after CAS, %	96.6
Post procedure	
Vascular complications	1.9%
Worsening renal function	0%
Statin therapy lifelong	100.0
High intensity	87.8
Moderate intensity	11.5

DAPT – dual antiplatelet therapy; GPIIb/IIIa – glycoprotein IIb/IIIa receptor inhibitors; SD – standard deviation.

observed in patients, divided in groups by gender, surgical risk or the embolic protection system used.

The stroke/CV death rate within 30 days in symptomatic and asymptomatic patients is shown in Table 4. A 68 year old symptomatic patient suffered a fatal stroke. No additional adverse events in symptomatic patients occurred thereafter. The 30 day stroke/CV death rate in the asymptomatic patient group was 5.4% and 3.9% after the exclusion of octogenarians.

Factors that influenced the risk of stroke/CV death/MI at a year follow-up in asymptomatic patients are shown in Table 5. Age ≥80 years (OR 7.64; 95% CI 2.43–24.03; $p = 0.001$), congestive heart failure (OR 4.86; 95% CI 1.06–22.34, $p = 0.04$) and structural valve disease (OR 7.70; 95% CI 2.59–22.87; $p < 0.001$) were determined as risk factors for an adverse event. In the multivariate analysis age ≥80

Table 3 – Cumulative incidence of adverse events in-hospital, within 30 days and one year.

Event	Total, % (n)	Age, % (n)			Age, % (n)		
		<70 y	≥70 y	p value	<80 y	≥80 y	p value
Stroke							
In-hospital	1.6 (3)	0	3.2 (3)		1.2 (2)	5.0 (1)	
30 days	4.1 (7)	2.4 (2)	5.8 (5)	0.44	2.6 (4)	15.8 (5)	0.07
1 year	4.5 (8)	3.6 (3)	5.5 (5)	0.72	3.3 (5)	15.8 (5)	0.09
MI							
In-hospital	0	0	0		0	0	
30 days	1.2 (2)	1.2 (1)	1.2 (1)	0.75	1.3 (2)	0	0.79
1 year	2.4 (4)	2.4 (2)	2.4 (2)	0.68	2.0 (3)	5.3 (1)	0.65
CV mortality							
In-hospital	0.5 (1)	1.1 (1)	0		0.6 (1)	0	
30 days	2.9 (5)	3.5 (3)	2.3 (2)	0.69	2.5 (4)	5.0 (1)	0.94
1 year	7.1 (13)	6.6 (6)	7.7 (7)	0.50	4.9 (8)	25.0 (5)	0.01
Stroke/CV death/MI							
In-hospital	2.2 (4)	1.1 (1)	3.2 (3)		1.9 (3)	5.0 (1)	
30 days	5.8 (10)	4.7 (4)	6.9 (6)	0.75	4.6 (7)	15.8 (3)	0.17
1 year	10.9 (19)	9.3 (8)	12.5 (11)	0.63	7.8 (12)	36.8 (7)	<0.01

CV – cardiovascular; MI – myocardial infarction; y – years.

Table 4 – Incidence of stroke/CV death in asymptomatic and symptomatic patients.

Period		Asymptomatic, % (n = 148)	Symptomatic, % (n = 24)	p
30 days	Total	5.4 (8)	4.2 (1)	0.80
	<80 years	3.9 (5)	4.4 (1)	0.91
1 year	Total	11.5 (17)	4.2 (1)	0.28
	<80 years	7.7 (10)	4.4 (1)	0.57

years (OR 4.41; 95% CI 1.06–18.36; $p = 0.04$) was the only predictor that increased the risk of an adverse event in the multivariate analysis. Structural valve disease showed a tendency of an increased complication risk (OR 3.57; 95% CI 0.90–14.14; $p = 0.07$).

Discussion

The study demonstrates acceptable serious adverse event rate (stroke, CV death, MI) 30 days and one year after CAS in a patient population with high prevalence of severe medical comorbidities. The 30-day and 1-year stroke/CV death/MI incidence was 5.8% and 10.9%. In the light of the results demonstrated in the Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy (SAPPHIRE) trial involving high risk patients [9], and the 30-day results in the CREST trial [7], we found our study outcome rates as comparable.

Several clinical trials have suggested CAS as a safe alternative for CEA [7,9]. The largest clinical trial that compared CAS and CEA to date, CREST, showed similar rates of the primary composite outcome – periprocedural stroke, myocardial infarction or death and subsequent ipsilateral stroke – among men and women with either symptomatic or asymptomatic carotid stenosis [7]. However, differences in patient selection and procedural risk profiles between clinical trials and everyday practice influence the clinical outcomes therefore questioning the generalizability of the results demonstrated in randomized clinical trials to clinical practice. The CREST trial enrolled standard surgical risk patients [7], whereas 86.4% of our study patients had at least one high surgical risk criteria mainly due to the high prevalence of severe coronary artery disease. A recently published study also showed high frequency of severe medical comorbidities among Medicare beneficiaries who underwent CAS between 2005 and 2009. Majority of the patients (91.2%) were at high surgical risk [10]. Inequality in patient baseline characteristics undergoing CAS as a part or outside clinical trials was suggested as a contributing factor to a higher adverse event rate in patients treated outside clinical trials in a study by Qureshi et al. The composite rate of periprocedural stroke, cardiac complications and/or death between patients treated within and outside clinical trials was 3.85% vs. 4.91%; $p = 0.0235$, respectively [11]. Therefore, the clinical outcome results both after CAS and CEA demonstrated by local registries should be considered during the management of carotid artery stenosis.

Table 5 – Factors associated with one year risk of stroke/CV death/MI in asymptomatic patients.				
Variables	**Univariate analysis**		**Multivariate analysis**	
	OR (95% CI)	*p* value	OR (95% CI)	*p* value
Age ≥80 years	7.64 (2.43–24.03)	0.001	4.41 (1.06–18.36)	0.04
Age ≥70 years	1.98 (0.69–5.67)	0.20		
Gender: Male	1.05 (0.35–3.19)	0.93		
Risk factors				
Hypertension	0.40 (0.13–1.22)	0.11	0.94 (0.21–4.21)	0.94
Smoking	1.92 (0.51–7.23)	0.33		
Diabetes	1.80 (0.57–5.65)	0.31		
Dyslipidemia	3.02 (0.37–24.46)	0.30		
Previous stroke/TIA	1.27 (0.69–2.33)	0.44		
High surgical risk	2.88 (0.36–22.96)	0.32		
Previous MI	2.31 (0.80–6.63)	0.12	1.72 (0.45–6.57)	0.43
Congestive heart failure	4.86 (1.06–22.34)	0.04	2.64 (0.49–14.27)	0.26
Atrial fibrillation	2.78 (0.86–9.00)	0.09	1.45 (0.32–6.49)	0.63
Structural valve disease	7.70 (2.59–22.87)	<0.001	3.57 (0.90–14.17)	0.07
High vs medium statin	0.32 (0.09–1.13)	0.08	0.74 (0.12–4.48)	0.74
Proximal vs distal protection	2.82 (0.61–12.98)	0.18	2.36 (0.38–14.86)	0.36
GPIIb/IIIa during procedure	1.07 (0.38–3.00)	0.89		

Variables showing a tendency (*p* < 0.20) of association with elevated 1-year risk of stroke/CV death/MI in the univariate analysis were included in the multivariate analysis.
CI – confidence interval; CV – cardiovascular; MI – myocardial infarction; OR – odds ratio; TIA – transitory ischemic attack.

The 30-day stroke/CV death rate in symptomatic and asymptomatic patients was 4.2% and 5.4%, respectively. According to the guidelines [12], the periprocedural stroke or death rate at 30 days after CAS should not exceed 3% in asymptomatic and 6% in symptomatic patients. Higher complication rate in our study asymptomatic patients was driven by patients with concomitant valve disease undergoing CAS before open heart surgery and the group of octogenarians. The majority (90%) of patients aged ≥80 years who underwent CAS were asymptomatic. After excluding these patients from the asymptomatic patient group, the complication rate was 3.2%. It raises the question about the benefits of revascularization strategies for patients with asymptomatic carotid stenosis and may indicate that pharmacological therapy could be the preferred treatment strategy in these patients. Although the risk of stroke in untreated asymptomatic patients increases with the severity of stenosis, it is still relatively low, between 1–3% per year [13,14]. During the last decade pharmacological treatment of atherothrombosis is significantly improved and is able to lower the risk of stroke [15], even to 0.34% per year [16]. However, evidence based data comparing contemporary intensive medical management alone with its combination with revascularization in the treatment of patients with asymptomatic carotid artery stenosis is lacking. Perhaps the currently ongoing CREST-2 trial will determine the most effective treatment strategy for asymptomatic patients by comparing CEA plus intensive medical management to intensive medical treatment alone and CAS plus intensive medical treatment to intensive medical treatment alone [17].

The incidence of adverse events in this study did not show any significant differences according to patient age <70 and ≥70 years. However, a crossover at an age of 70 years, when patients tend to benefit less from CAS was shown in the CREST trial [8]. This association was also demonstrated in a meta-analysis of the Endarterectomy versus Angioplasty in Patients with Symptomatic Severe Carotid Stenosis (EVA-3S) trial, the Stent-Protected Angioplasty versus Carotid Endarterectomy (SPACE) trial, and the International Carotid Stenting Study (ICSS). No other subgroups, except age ≥70 years had a significantly higher risk of the primary outcome event (*p* = 0.0053) [18]. However, we found adverse events more frequent in the group of octogenarians. Age ≥80 years was associated with an increased risk of stroke/CV death/MI both by the univariate (OR 7.64; 95% CI 2.43–24.03; *p* = 0.001) and multivariate (OR 4.41; 95% CI 1.06–18.36; *p* = 0.04) analysis. In addition, an unsuccessful stent placement in one patient and two technical failures which led to CEA in our study were all in octogenarians. Increased complication rate in octogenarians has been shown in several other studies [2,19–21]. Procedure related risk factors like significant vessel tortuosity, aortic arch elongation and calcification, more frequently observed in the elderly are suggested to increase the risk of embolic events [22–24]. The differences between age and the risk of adverse events demonstrated in our study compared to the results demonstrated in other studies could be explained by the similar incidence of medical comorbidities in patients aged <70 and ≥70 years. Vessel anatomical characteristics, advanced age and

the low sample size could have influenced the results in the group of octogenarians.

All patients undergoing CAS in our center routinely receive intensive medical treatment and risk factor modification recommendations as patients with coronary artery disease. High intensity statin therapy was prescribed for 87.8% of patients. It has been reported that higher doses of statins have a more potent effect on plaque stabilization. Plaque echogenicity is significantly increased in patients with carotid disease receiving high compared to low dose statin therapy [25]. The use of statins pre- and post-procedure was associated with lower adverse event rate both after CEA [26] and CAS [27,28] in other clinical studies. High dose atorvastatin therapy in patients with recent stroke or TIA and without known coronary heart disease has been shown to reduce the risk of stroke in the SPARCL trial [29]. However, our study did not show any significant differences of adverse event rates in patients receiving medium or high dose statin therapy.

Proximal embolic protection device Mo.Ma (Invatec/Medtronic Vascular Inc, Santa Rosa, California) was used in 23.7% procedures in our study. Several studies have shown lower microembolization rate by transcranial Doppler during CAS [30] and lower number of cerebral ischemic lesions detected by DW-MRI [31,32]. However, our study did not find any significant differences in the frequency of any adverse outcomes between the groups with proximal vs distal protection. Our findings are in line with a recently published large multicenter analysis of proximal versus distal embolic protection for CAS. The study showed that both types of protection devices were associated with similarly low rates of periprocedural and 30-day risks of stroke/death [33].

This study has some limitations. It is conducted in a single center and with a small sample size. Considering the small sample size, the clinical outcome analysis should be interpreted with caution. No independent neurologic evaluation was performed. Due to the loss of follow-up in 10 patients (5.5%) in whom the living status was confirmed, the actual 30-day and 1-year stroke and MI rates could differ.

Conclusions

Our study demonstrated good clinical outcome results in a high-risk patient cohort treated with CAS by interventional cardiologists. Similar adverse event incidence following CAS was observed in patients <70 and ≥70 years. Adverse event rate in symptomatic patients did not exceed the guideline recommended range while in asymptomatic patients it was increased and more evidence based data are needed to guide the treatment strategy in these patients.

Conflict of interest
None.

Funding body
None.

Ethical statement
I declare, on behalf of all authors, that the research was conducted according to Declaration of Helsinki.

Informed consent
I declare, on behalf of all authors, that informed consent was obtained from all patients participating in this study.

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