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Carotid Artery Stenosis in Patients with Aortic Valve Stenosis – Short-Term Outcomes after Carotid Artery Stenting

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Abstract

Background: Carotid artery stenosis occurs in 8–13% of patients with degenerative aortic stenosis. The risk of new postoperative stroke after cardiac surgery is thought to be two- to four-fold higher in patients with concomitant carotid stenosis. We evaluated the results of carotid stenting in patients with aortic valve stenosis.

Methods: We retrospectively analysed internal database containing patients after carotid artery stenting and identified patients with severe aortic valve stenosis. Then we evaluated the number of major complications in 30 days' follow-up.

Results: Overall, 246 CAS procedures were performed among which the complications rate was 2.0% (3 deaths, 1 NSTEMI, 1 stroke). 14 of the procedures were conducted in patients with aortic valve stenosis. There were two (14.29%) procedural-related deaths. There were no neurological events and no instances of myocardial infarction. Both deaths occurred after the second CAS procedure in female patients. The correlation between death and the second CAS procedure was at the margin of significance (p=0.05). There were no other significant covariates associated with incidence of death (age p=0.63; female sex p=0.375; coronary artery disease p=0.63; diabetes mellitus p=0.3; hypercholesterolemia p=0.76; congestive heart failure p=0.45; previous ischemic stroke or TIA p=0.7; double vessel stenosis p=0.65; occlusion of contralateral internal carotid artery p=0.76; aortic valve area p=0.85).

Conclusion: The results imply that patients with aortic stenosis are at high risk of carotid revascularization. It should be emphasized that deaths occurred after the second CAS. Thus, it is possible that such patients are at the highest risk of periprocedural death.

Keywords: Carotid stenosis, Carotid stenting, Valve diseases

Abbreviations: **AVR:** Aortic Valve Replacement, **CABG:** Coronary Artery Bypass Grafting, **CAS:** Carotid Artery Stenting, **CEA:** Endarteriectomy, **COPD:** Chronic Obstructive Pulmonary Disease, **CS:** Carotid Stenosis, **DAS:** Degenerative Aortic Stenosis, **ESC:** European Society of Cardiology, **NSTEMI:** Non-st Segment Elevation Myocardial Infarction, **TAVI:** Transcatheter Aortic Heart Valve, **TIA:** Transient Ischemic Attack

Introduction

Carotid Stenosis (CS) is considered an important cause of ischemic stroke. Most authors report that, CS may account for about 20% of episodes [1,2]. Three therapeutic options for CS are available. Medical management alone is reserved for patients with carotid artery occlusion, asymptomatic patients with stenosis <60% or with a life expectancy of less than 5 years and for symptomatic patients with stenosis <50%. Other patients with carotid stenosis should have endarteriectomy (CEA) Or Carotid Artery Stenting (CAS) considered [3].

The goal of invasive treatment of carotid artery stenosis is to reduce the number of cerebral ischemic episodes. It has been proven that CEA is highly beneficial for patients with symptomatic carotid stenosis [4,5]. CEA results are less spectacular in patients with asymptomatic lesions, although the invasive strategy has proven advantageous over conservative treatment in selected groups [3,6,7].

CAS is a newer method. It has evolved considerably in the last 15 years. Randomized trials comparing CAS with conservative treatment are not available. The results of studies comparing CAS with CEA have been not conclusive about the role of CAS. However, based on SAPPHIRE study results (which showed that among patients with severe CS and serious comorbidities CAS is not inferior to CEA) , CAS should be considered in high surgical risk patients requiring revascularization [7].

European Society of Cardiology (ESC) guidelines have recommended CAS as an alternative to CEA in symptomatic patients with high surgical risk (Class IIa). In addition, the guidelines advocate CAS in asymptomatic patients with indications for revascularization if CAS is performed in high-volume centres with rates of peri-procedural stroke or death below 3% (Class IIb), and in symptomatic patients in centres with major complications thresholds below 6% (Class IIb). However, endarterectomy is still considered a first-choice method [3].

The recent large trial CREST found that there are no significant differences in long-term outcomes between CAS and CEA with regard to the whole cohort. However, there were differences between particular groups of patients. It appears that it would be helpful to assess the usability and safety of each method in specific clinical situations.

Data about result of CAS in patients with Degenerative Aortic Stenosis (DAS) are severely limited. In this study we evaluated the results of CAS in patients with severe aortic valve stenosis.

Methods

Overall information

All CAS procedures in the Department of Cardiology of Pomeranian Medical University were conducted by two experienced interventional cardiologists. The patients who were treated with CAS were followed up after 1, 3, 6 and 12 months during control Ultrasonography (US) examination of the carotid arteries. The patients who had US examinations in others centres were followed up by phone interviews. The records from hospitalization and the follow-ups were included in the internal database.

We retrospectively analysed the database and identified patients with severe aortic valve stenosis. Then we evaluated the number of major cardiovascular complications in 30 days' follow up: myocardial infarctions, strokes, TIA and deaths.

Symptomatic carotid artery stenosis was defined as the presence of TIA or stroke affecting the corresponding territory within the previous 6 months. Severe aortic valve disease was defined according to ESC recommendations [8,9].

Statistical analysis

Continuous variables are presented as the mean ± standard deviation, and they were compared using the Student's t-test. Categorical variables are presented as frequencies and percentages, and they were compared with Fisher's exact test. P-values less than 0.05 were considered statistically significant In the case of bilateral stenosis, two CAS procedures were performed. The minimum interval between procedures was 5 weeks. Therefore, we analysed each procedure separately.

Results

Patients

The analysis of an internal database revealed that 12 CAS procedures were performed in patients with significant aortic valve stenosis and two with borderline aortic valve stenosis (aortic valve area 1,1 and 1,2 cm2). Ten patients were treated for single vessel stenosis, and two patients underwent treatment twice (double vessel stenosis). In the case of double vessel disease, the procedures were performed with at least 30-day intervals. All patients except the one with borderline DAS qualified for cardiac surgery (9 patients for open heart surgery, one for transapical TAVI). The minimum interval between CAS and surgery was 6 weeks due to dual antiplatelet therapy. (**Table 1**) provides the patients' demographic and clinical parameters.

Procedure

All patients had ultrasound examination of the carotid arteries, as well as complex echocardiography and coronarography with cerebral angiography prior to CAS. Cardiac surgery consultation and vascular surgery consultation were obtained after invasive diagnostics, but before CAS. The procedure was performed in symptomatic patients with stenosis >70% in angiography or in asymptomatic with stenosis >80%. Quantitative arteriography was performed in all cases. Distal embolic protection was used in 12 procedures. Two CAS were performed with a proximal protection device (Mo.Ma system). In all cases stents were used (**Table 2**). The patients were hydrated before the procedure in order to optimize loading conditions. Hypotensive drugs were discontinued at least 24 hours before CAS. Patients with DAS had endocavital electrode established to prevent bradycardia. Those patients were treated with catecholamines only if significant hypotension occurred. After CAS all the patients were observed in a cardiac intensive care unit for 24–48 hours. Careful hemodynamic parameter monitoring continued throughout the hospitalization period.

Clinical outcomes

Overall, 246 CAS procedures were performed in the Department of Cardiology of Pomeranian Medical University. The complications rate was 2.0% (3 deaths, 1 NSTEMI, 1 stroke). We identified 14 CAS procedures in patients with aortic valve stenosis. Among 14 CAS procedures, there were 2 (14.29%) procedurally related deaths. There were no neurological events and no instances of myocardial infarction during the in-hospital period or in 30 days' follow-up. No variable except the number (succession) of procedures was significant for the prediction of death (**Table 3**).

Table 1. Patient's demographic and clinical parameters.

Demographic parameters	Patients n=12 (%)
Age (years), mean ± standard deviation	74,58 ± 6,87
Male	6 (50%)
Clinical parameters	**Patients n=12 (%)**
CAD	8 (67%)
Previous Myocardial Infarction	2 (17%)
Diabetes Melitus	5 (42%)
Arterial Hypertension	12 (100%)
Hypercholesterolemia	10 (83%)
CHF with EF <50%	2 (17%)
Ischemic Stroke or TIA <6 months	4 (33%)
Ischemic Stroke or TIA ≥6 months	4 (33%)
Single Vessel Stenosis	7 (58%)
LICA	2 (17%)
RICA	5 (42%)
Double Vessel Stenosis	3 (25%)
Contralateral occlusion	2 (17%)
AVA, mean ± standard deviation	0,775 ± 0,20

CAD: Coronary Artery Disease; CHF: Congestive Heart Failure; EF: Ejection Fraction; IS: Ischemic Stroke; TIA: Transient Ischemic Attack; LICA: Left Internal Carotid Artery; RICA: Right Internal Carotid Artery; AVA: Aortic Valve Area

Table 2. Stent systems used in the study population (n=14).

Stent	Procedures n=14 (%)
Cristallo Ideale Carotid Self-Expanding Hybridstent System	n=7 (50.00%)
RX Acculink Carotid Stent System	n=4 (28.60%)
Xact Carotid Stent System	n=2 (14.30%)
MULTI-LINK VISION RX Coronary Stent System	n=1 (6.25%)

The correlation between death and the second CAS procedure was at the limits of significance (p=0.05).

Discussion

CS occurs in 8–13% of patients with degenerative aortic stenosis [10,11]. The frequency differs significantly between patients depending on whether they have coronary artery disease (CAD). Terramani et al. found that the prevalence of CS in patients with DAS and CAD was more than six-fold higher than with isolated DAS [10]. The frequency of carotid stenosis in patients with other valve defects has not been clarified. The risk of new post-operative stroke after cardiac surgery has been estimated at

Table 3. Distribution of demographic and clinical parameters according to procedures (n=14). The correlation between parameters and death.

Demographic parameters	Procedures n=14 (%)	P
Age (years), mean ± standard deviation	75.3 ± 6.7	0.36
Female	8 (57%)	0.375
Clinical parameters	Procedures n=14 (%)	
CAD	9 (64%)	0.63
Diabetes Mellitus	7 (50%)	0.30
Hypercholesterolemia	12 (86%)	0.76
CHF with EF <50%	3 (21%)	0.45
Ischemic Stroke or TIA	8 (57%)	0.70
Double Vessel Stenosis in time of CAS	3 (21%)	0.65
Contralateral occlusion	2 (14%)	0.76
Previous contralateral CAS	2 (14%)	0.05
AVA, mean ± standard deviation	0.757 ± 0.19	0.85

CAD: Coronary Artery Disease; CHF: Congestive Heart Failure; EF: Ejection Fraction; IS: Ischemic Stroke; TIA: Transient Ischemic Attack; LICA: Left Internal Carotid Artery; RICA: Right Internal Carotid Artery; AVA: Aortic Valve Area

0.8%–4% [12,13]. The risk is higher for valve replacement (1.9%) and combined procedures (AVR and CABG 2.9%) than for isolated CABG (1%) [12]. The risk of stroke is thought to be two- to four-fold higher in patients with concomitant CS. According to Naylor et al., the risk of postoperative stroke increases to 3% in patients with unilateral CS>50%, to 5% in patients with bilateral CS >50% and to 11% with carotid occlusion [14]. The coexistence of degenerative aortic stenosis or other valve disease with severe CS appears to be an important issue in eligibility for invasive treatment. Therefore, this group of patients may require patient-specific approaches to achieve treatment goals. Several treatment options are available.

Carotid revascularization before cardiac surgery is a common practice. Many data suggest that patients with symptomatic carotid stenosis undergoing carotid revascularization previous to cardiac surgery are at lower risk of stroke. Unfortunately, either carotid endarterectomy or carotid stenting may cause cardiovascular instability, which is particularly undesirable in patients with DAS. CEA is thought to be more often associated with myocardial infarction than CAS [14]. However, hemodynamic depression, defined as a drop in systolic pressure below 90 mmHg and, or heart rate to less than 60 beats per minute may occur in more than 30% of patients undergoing CAS [15-17]. The incidence rate among our patients is estimated to be 30%. Performing CAS, CEA or other non-cardiac surgeons should be aware of the danger of hemodynamic stress in patients with DAS. Careful hemodynamic monitoring and proper peri-procedural proceeding, with optimization of loading condition are critical [18]. Agarwal et al. performed a case-control study to assess the risk of non-cardiac surgery in patients with moderate and severe aortic valve stenosis. The investigators pointed out that the presence of DAS adversely affected the rate of postoperative myocardial infarction and 30-day mortality [19]. Unfortunately, data on the safety and effectiveness of carotid revascularization in patients with DAS are limited. Kar et al. presented a study

evaluating carotid interventions in patients with aortic valve stenosis. The study included 52 patients. Carotid artery stenting or angioplasty alone (2 patients) was successful in 51 cases. No strokes were observed in 30 days' follow up. Five patients (10%) expired before AVR [20].

Similarly, in our study we did not observe any significant neurological events. One patient died of cardiovascular causes, and one of cardiorespiratory failure. The first cardiovascular death occurred in a 76-year-old female patient with bilateral carotid stenosis, history of ischemic stroke, severe degenerative aortic stenosis and coronary artery disease, after the second stage of carotid revascularization. The patient had already qualified for concomitant Aortic Valve Replacement (AVR) and Coronary Artery Bypass Grafting (CABG). The decision about CAS was made by consensus of the cardiac surgeon, vascular surgeon, neurologist and interventional cardiologist. The first CAS was performed without significant complications – hemodynamic depression was observed after CAS, but with good response to pharmacotherapy. The procedure on the contralateral artery was made after a 6-week interval. Despite good angiographic results, the second procedure was complicated by cardiogenic shock. The patient was transferred in serious condition to the intensive care unit where she died day after CAS. The direct cause of death was cardiac arrest.

The second death was due to composite cardiac and respiratory failure. It occurred after the second CAS procedure in an 83-year-old female patient with bilateral carotid stenosis, severe degenerative aortic stenosis, severe tricuspid regurgitation, moderate aortic and mitral regurgitation, chronic heart failure with ejection fraction 25%, chronic anaemia and severe chronic obstructive pulmonary disease. The therapeutic strategy was based on the consensus of the multidisciplinary team. Due to comorbidities and very high surgical risk, the patient qualified for a TAVI procedure. Before TAVI, two-stage carotid artery stenting was planned. As in the previous case, the first CAS was performed without significant complications. The interval between the procedures was about 2 months. The long delay resulted from a hospitalization in an intensive care unit (>30 days after the first CAS) due to respiratory failure. A second CAS was performed after stabilization of the patient's state. The patient required a prolonged infusion of pressor amines, although the blood pressure stabilized on the third day after the procedure. Despite temporary hemodynamic stability, the next day the patient's condition deteriorated due to worsening circulation and respiratory function. Shortly afterwards the patient died from cardiorespiratory failure. In summary, both deaths were procedure-related but in fairness, it should be noted that the therapies performed on the second patient were considered to be last-hope therapies. It should be emphasized that both deaths occurred after the second CAS procedure, in female patients with bilateral CS and severe DAS. Reviewing the whole group of 246 procedures, we had only three more cardiovascular events. Thus, maybe patients with aortic valve stenosis requiring double CAS, are at the highest risk. One should consider performing the CAS procedure only for one artery, and then patients should be operated on with an acceptance of increased risk of the peri-procedural stroke during the AVR procedure. We are aware that analysed group is small, however there is no available data regarding the issue. A possible cause of failure of the second CAS could be the postponement of surgery. It is not clear if contralateral CAS could affect hemodynamic response during the second procedure.

A second possible scenario of treatment is simultaneous carotid revascularisation and the valve replacement instead of a phased treatment. Yoda et al. reported that peri-procedural stokes after simultaneous CEA and valvular surgery occurred in 10.1 % of patients. In addition the early mortality rate was 10.1% [21]. Outcomes of simultaneous CAS and valvular surgery have not been established. Mendiz et al. reported a series of 30 patients who received carotid artery stenting directly followed by cardiac surgery (CABG or combined procedure). All patients were pre-treated with aspirin. Unfractioned heparin was used during CAS. Clopidogrel was administrated after surgery if major bleeding was excluded. The authors reported three surgically related deaths and one TIA [22]. In our centre, we did not perform simultaneous procedures.

There is also the opinion that cardiac surgery can be performed with acceptable risk of neurological events in patients with carotid stenosis, without carotid revascularization. Mahmoudi et al. performed a retrospective analysis of 878 consecutive patients who underwent CABG. They compared outcomes of cardiac surgery in patients with (n = 117) and without carotid stenosis (n = 761). There were no significant differences between the groups for in-hospital mortality or stroke rate [23]. The low risk of CABG in patients with asymptomatic CS was also reported by Gaudino et al. The in-hospital results were similar between patients pre-treated with CEA or treated conservatively. However, neurological events were more frequent at mid-term follow up in the no-endarteriectomy group [24]. Li et al. reported that only 5.3% of postoperative strokes were of the large vessel type. In the study, investigators included a total of 4335 patients who underwent cardiac surgery. Seventy-six (1.8%) patients developed postoperative neurological complications. Only four patients developed stroke in territory corresponding to large vessel disease. However, incidents of strokes were four-fold higher in patients with significant carotid stenosis than in the entire cohort (7.5% vs. 1.8%) [25].

Presented facts show that treatment decisions for patients with carotid stenosis and valvular disease are often very difficult. Unfortunately most published data regarding the problem come from small series studies and case reports. In addition, the cohorts in different studies are often heterogeneous. Currently, two comparable invasive treatment methods are available for patients with CS. It seems by now, based on various comments, that it is not essential to assess methods in the general population with CS, but to evaluate the usefulness of the method in a particular clinical situation instead.

Limitations

Our study includes a relatively small number of patients. Data was collected retrospectively. We did not compare CEA and CAS. However, there is no large, prospective, multi-centre trial comparing results of CAS and CEA in patients with valve defects.

Another limitation is that the study group includes patients with other severe comorbidities like coronary artery disease, heart failure or very severe chronic obstructive pulmonary disease. This makes a non-homogeneous cohort; however, the fact that carotid artery stenting was performed in the highest-risk patients in our study makes the results even more interesting.

Conclusion

The results from this and other small series studies imply that CAS is worth considering in patients with concomitant aortic valve disease and carotid stenosis. However, more research is needed to clarify CAS safety and its usefulness in this particular group of patients. A question that arose during the analysis is whether patients with double vessel disease require treatment of both stenoses. The complications occurred after the second CAS. It has not been determined whether single artery revascularization would be sufficient to improve safety during surgery. Our limited experience suggests the avoidance of bilateral procedures in patients with severe, symptomatic AS, especially with other commorbities, such as COPD.

Impact on Daily Practice

There is no clear recommendations for treatment of patients with concomitant carotid artery stenosis and degenerative aortic valve stenosis. Moreover, existing literature is poor about data regarding the invasive treatment of this particular group of patients. As such the article may help in deciding process.

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