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ORIGINAL ARTICLE

Same-day carotid artery stenting and aortic valve surgery: a minimally invasive option for high-risk patients

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Summary

Introduction: The etiology of aortic valve stenosis (AS) is multifactorial; hypertension, hyperlipidemia, and diabetes mellitus are the most common risk factors for the development of the disease. The same factors increase the incidence of atherosclerosis in the peripheral arterial vessels. Hemodynamic disturbance in both diseases increases the risk of cerebrovascular symptomatology. Due to the overlapping of the symptoms in patients with concomitant aortic valve stenosis and carotid artery disease, the indication for treatment is not always straightforward. There are different strategies for treatment; same-day or simultaneous surgery, staged procedure, transcatheter technique, or medical treatment.

Aim: The aim of our study is to observe the feasibility and safety of same-day SAVR and CAS in patients with concomitant severe aortic valve and carotid artery stenosis.

Material and methods: A prospective non-randomized study performed from August 2015 to August 2023 included thirty-four patients who underwent same-day SAVR (simple or in combination with other cardiac surgery procedures) and CAS intervention.

Results: The study included 34 patients with concomitant carotid and aortic disease. The majority of patients had SAVR with CABG procedure. In total, MACCE was reported in 3 patients.

Conclusion: The guidelines for treatment strategy are unclear due to a lack of studies about this subject. Surgical aortic valve replacement (SAVR) and carotid artery endarterectomy (CEA) done simultaneously, can yield favorable results but could be excessively invasive for high-risk patients. In these cases, surgical aortic valve replacement and carotid artery stenting (CAS) are feasible, less invasive option.

Keywords: carotid artery stenting, aortic valve stenosis, surgical aortic valve replacement

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INTRODUCTION

The incidence of aortic valve stenosis (AS) in the population above the age of 65 is more than 2 % (1). The etiology of AS is multifactorial; hypertension, hyperlipidemia, and diabetes mellitus are the most common risk factors for the disease (2). The same factors increase the incidence of atherosclerosis in the peripheral arterial vessels. The prevalence of extracranial internal carotid artery (ICA) stenosis in patients with severe aortic stenosis (AS) reaches up to 33% of patients having carotid stenosis >50% (3). Hemodynamic disturbance in both diseases increases the risk of cerebrovascular symptomatology. Severe AS decreases cardiac output, and consequently produces syncope in patients with peripheral vascular dilatation (4, 5). Reduction of the blood patency through the stenotic carotid artery can result in loss of consciousness and syncope (6, 7, 8). Due to the overlapping symptoms in patients with concomitant aortic stenosis (AS) and carotid artery disease, determining the appropriate treatment is not straightforward. There are different strategies for treatment; same-day or simultaneous surgery, staged procedure, transcatheter technique, or medical treatment (9). Treatment guidelines remain unclear due to the lack of sufficient studies on this topic (9). Surgical aortic valve replacement (SAVR) and carotid artery endarterectomy (CEA) can yield favorable results but could be excessively invasive for high-risk patients. In these cases, surgical aortic valve implantation (SAVR) and carotid artery stenting (CAS) are feasible, less invasive options.

The aim of our study is the feasibility and safety of same-day SAVR and CAS in patients with concomitant severe aortic valve and carotid artery stenosis.

MATERIAL AND METHODS

A prospective non-randomized study performed from August 2015 to August 2023 included thirty-four patients who underwent same-day SAVR (simple or in combination with other cardiac surgery procedures) and CAS intervention.

The inclusion criteria: Severe aortic valve stenosis indicated for SAVR in the elective patients with concomitant significant carotid artery stenosis suitable for CAS procedure.

Exclusion criteria were: Cardiac reoperation, emergent and urgent cases, carotid artery stenosis is not suitable for CAS, history of bleeding disorder.

All participants were exanimated by a standard perioperative protocol of our Institute.

The cardiologist performed physical and echocardiographic examinations. The presence of significant aortic valve stenosis was evidenced by measuring the aortic valve area (AVA) less than 1cm^2, mean pressure gradient more than 40 mmHg, and peak jet velocity more than 4 m/s. Also, the functions of the left and right ventricles and other valves were checked. Coronary angiography was performed in all patients to exclude significant coronary artery disease.

The preoperative physical exam was performed in all patients. The CA disease was revealed by a history of cerebrovascular events or carotid bruit on the auscultatory exam. The patients were considered asymptomatic if they had no history of TIA and stroke 120 days before the procedure.

The angiologist performed a color duplex scan to evaluate carotid artery stenosis, plaque characteristics, and carotid blood flow velocity before the procedure. Additionally, a computed tomography (CT) angiography scan confirmed the degree of CA stenosis, characteristics of the carotid plaque, and anatomy of the cerebral circulation.

The stenosis was measured using the NASCET (North American Symptomatic Carotid Endarterectomy Trial) criteria.

The indication for carotid revascularization was artery diameter reduction of more than 80% in asymptomatic or >50% in the symptomatic patients by the NASCET criteria. In patients with bilateral CA disease, a choice of the artery to treat was made according to the plaque's severity and morphology.

The vascular surgeon and radiologist provided the final approval for CAS according to the plaque's anatomic characteristics for saving stent implantation.

Unfavorable characteristics were tortuosity of the carotid vessels, extreme calcification, pinhole stenosis, total artery occlusion, circumferential calcification (more than two-thirds of the vessel circumference), significant vessel angulations, and severe aortic arch calcification.

In patients with bilateral CAD, a choice of the artery to treat was made according to the clinical criteria, severity the morphology of the plaque, or both.

Carotid artery stenting procedure protocol

CAS was performed in the catheterization laboratory under local anesthesia before cardiac procedures. After the procedure, neurological status was evaluated to detect a newly created cerebrovascular disturbance. All patients received 100mg Aspirin starting two days before the procedure. The percutaneous transfemoral approach was used. Heparin was administered at a dose of 1mg/kg. The distal cerebral protection device (Emboshield Abbot Vascular and Spider) was used in all patients. Predilatation of the stenosis was done before the placement and final stent expansion. Balloon expandable stents (Xact Abbot Vascular, Cristallo Invatec, and Carotid WALLSTENT Boston Scientific) were deployed into the common carotid artery. The results of the CAS were considered successful if residual stenosis was ≤ 20%, and if complications such as stroke or TIA did not occur. Within 1 hour of completion of the procedure, patients were transferred to the

cardiac surgery operating theatre. During that period, patients received intravenous heparin via infusion pump according to activated clotting time (ACT) value, which was measured on an hourly basis. The aim was to maintain ACT around 200 seconds (10).

Aortic valve replacement

Approximately 15 minutes after the CAS procedure the patient was transferred into the operation theater. During this period their neurological function was checked.

The surgical procedure was performed through the conventional sternotomy under general heparinization (ACT >480s). Standard ascending aorta cannulation and venous cannulation were performed, and cardio-pulmonary bypass was performed with a standard non-pulsatile technique. The crystalloid or cold blood cardioplegia was used. The aortic valve replacement was performed through the transversal aortotomy using the mechanical or biological stented prosthesis. After completion of the intervention and weaning from the cardiopulmonary bypass, a complete reversal of heparin was done by infusion of full dose protamine and antifibrinolytic agent (tranexamic acid).

Periprocedural pharmacological protocol

Dual antiplatelet therapy was administered early after the procedure, providing that chest tube bleeding was less than 50 cc for three consecutive hours. Six hours after the cardiac procedure, clopidogrel 300 mg is given as a loading dose in the intensive care unit (ICU) via nasogastric tube, followed by 75mg/day for one month postoperatively.

The anticoagulation was started on the first postoperative day and titrated according to the international normalized ratio (INR). Implanted biological prostheses need three months of anticoagulation treatment, while patients with mechanical prostheses take a long-life therapy.

Aspirin 100 mg/day was continued from the first morning after the procedure for the remainder of the patient's life.

RESULTS

The study included 34 patients with concomitant carotid and aortic disease. Most of the patients were males, elderly, dominantly with NYHA 2 and 3. The majority had hypertension and hyperlipoproteinemia, and a half of them were diabetics **(Table 1)**.

The ejection fraction was near the lower bound, majority had MR 0 or 1. A small number of patients had CV events before this hospitalization, but half of the patients had symptoms of carotid disease, mostly bilateral. The majority of patients had stenosis above 80% in an examined artery, and below 70% in a contralateral artery **(Table 2)**.

Table 1. Preoperative characteristics 1

	N (%) / mean±sd / med(IQR)
Age (yrs)	70.1±5.2
Gender male	21 (61.8%)
NYHA	
1	2 (5.9%)
2	14 (41.2%)
3	18 (52.9%)
HTA	33 (97.1%)
HLP	26 (76.5%)
Heredity	25 (73.5%)
DM	14 (41.2%)
PVD	8 (23.5%)
CRF	2 (5.9%)
COPB	1 (2.9%)
Previous MI	3 (8.8%)
Type of MI	
NSTEMI	2 (5,8%)
STEMI	1 (2,9%)
Time of MI >90 days	3 (8,8%)
Heart failure	5 (14.7%)
EuroScore II	2.84 (4.78)

Table 2. Preoperative characteristics 2

	N (%) or mean±sd
EF (%)	48.4±12.0
MR	
0	9 (26.5%)
1	18 (52.9%)
2	5 (14.7%)
3	2 (5.9%)
CV events	6 (17.6%)
CVI	3 (8.8%)
TIA	3 (8.8%)
Preop. TIA	4 (11.8%)
Preop. CVI	2 (5.9%)
Carotid disease sympt.	11 (44%)
Type of carotid disease	
Unilateral	6 (17.6%)
Bilateral	28 (82.4%)
Stenosis degree	85.2±7.5
Stenosis range	
60-69	0 (0%)
70-79	4 (11.8%)
80-89	17 (50%)
90-100	13 (38.2%)
Count. lat. stenosis degree	49.8±21.7
Count. lat. stenosis range (%)	
<50	13 (38.2%)
50-70	17 (50%)
70-99	3 (8.8%)
100	1 (2.9%)

The majority of patients had SAVR with CABG procedure, no complications during the procedure were reported, and three patients had CVI in the postoperative course (one after REDO SAVR, one after SAVR+CABG and one after simple SAVR procedure- 2,9% each). Inotropes were applied in half of patients **(Table 3)**.

Table 3. Intraoperative characteristics

	N (%) / mean±sd / med(IQR)
Cardiac procedure type SAVR +	
CAPB	19 (55.9%)
TVP	1 (2.3%)
MVR	1 (2.3%)
REDO SAVR	2 (5.9%)
Clamp time	77.5±35.3
Pump time	103.5±44.5
Complications during CAS	0
Postop. TIA	0
Postop. CVI	3 (8.8%)
Neurodeficiency	3 (8.8%)
Deficit type	
ischemia	3
Inotrops	16 (47.1%)
Drainage 6h	250 (300)
Drainage 24h	500 (375)
Extubation time	11.5±3.6

Revision of hemostasis was applied in several patients. Several patients had atrial fibrillation, pleural edema, and urinary infection. None of the patients were returned to ICU, and none of them died after the procedure **(Table 4)**.

Table 4. Postoperative characteristics

	N (%) / mean±sd / med(IQR)
Revision of haemostasis	6 (17.6%)
Disorientation	6 (17.6%)
Periop. MI	0
AF	7 (20.6%)
Th AF – amiodaron	7
Wound infection	0
Mediastinitis	0
Urinary infection	1 (2.9%)
Pleural effusion	7 (20.6%)
ICU return	0
Death outcome	0
ICU stay (days)	2 (2)
In hospital stay (days)	8 (8)

In total MACE was reported in 3 patients, and all 3 had CVI in the early postoperative period. Other adverse events such as MI and death were not registered **(Table 5)**.

Table 5. Clinical outcomes within 30 days after SAVR and CAS

Major events 30 days	**N (34)**
Stroke	3
Transient ischemic attack	0
Myocardial infarction	0
Death	0
Death/Stroke/MI	3

DISCUSSION

The risk of major adverse clinical events like transient ischemic attack (TIA), stroke (CVI), myocardial infarction (MI), and death in the periprocedural period (30 days) after SAVR surgery is around 5,7% for simple aortic valve surgery (11), and that risk significantly increases in patients with carotid artery disease, who underwent aortic valve replacement (12). Consequently, treatment of concomitant carotid and cardiac disease (aortic valve disease or coronary artery disease) is very important to reduce adverse events, but clear guidelines do not exist (13). There are three different strategies for the treatment of significant carotid stenosis, medical therapy, carotid artery stenting, and carotid endarterectomy, and the choice of technique and time of treatment concomitant carotid and heart disease is still a topic of discussion (14, 15). Correction of the carotid disease before open heart disease (staged procedure) reduces the incidence of cerebrovascular events but increases the probability of myocardial infarction, due to this complication same-day or simultaneous treatment was implemented (16,17). On the other hand, some studies showed that simultaneous CEA and CABG surgery increases the risk of death and serious morbidity (17,18). There is a described significant hemodynamic depression during a CAS procedure in patients with concomitant severe aortic valve and carotid diseases. The deployment of balloon-expandable stents increased rates of persistent hemodynamic instability due to carotid sinus stimulation during the procedure. Pressure drop in patients with significant aortic stenosis could produce significant myocardial ischemic attack with rhythm disturbance (19). There were no adverse events during stenting in our study population, which is encouraging, especially when it comes to high-risk patients in whom simultaneous surgery procedures increase postoperative adverse events. Brigitte Gansera et al. showed results of simultaneous carotid endarterectomy and cardiac surgery with a total of 5.2% mortality in the 30-day follow-up. Cerebrovascular events (transient ischemic attack and stroke) have been registered in 1.8% and 2.6% of patients (20). Compared to the presented results in the literature, our strategy for this group of patients reached similar results. Karolina Dzierwa et al. in their study had very satisfactory results in which they investigated same-day CAS and OHS (21). In their study, MACE did not occur during or immediately after CAS, and the percentage of 4.3% of MACE after OHS relates to very high-risk patients. Their study showed that the same-day approach could be a good modality of treatment. In our study, we registered 3 cerebrovascular events. One CVI occurred after REDO SAVR, one after SAVR+CABG, and one after simple SAVR, which is 2.9% for each one. We did not register other major cardiovascular adverse events such as MI or death 30 days after the procedure. Minimally invasive SAVR and transcatheter aortic valve implantation in combination with CAS could be excellent treatment options in high-risk patients. Excluding the cardio-pulmonary bypass, decreasing the aortic manipulation, and shortening the cross-clamp time are the advantages of the

minimally invasive approaches (22,23). There is a lack of studies that show the results of same-day treatment of the concomitant carotid and aortic valve stenosis.

CONCLUSION

Patients with severe, concomitant carotid and cardiac aortic valve diseases require cautious assessment and a multidisciplinary approach. Although CAS precedes open heart surgery (OHS) is not without risks, it is a very good choice in preventing fatal outcomes during SAVR. To reduce the risk of fatal outcomes, the preferred approach for treating patients with aortic stenosis, carotid artery stenosis, or both involves minimally invasive procedures such as TAVI or CAS. However, in high-risk patients, the treatment approach may involve same-day or simultaneous procedures, combining traditional methods such as SAVR and CEA with less invasive techniques like TAVI and CAS. There are no definitive guidelines in the literature regarding the best method of treatment; however, this study may contribute to more informed decision-making in the future for patients with concomitant carotid and heart disease.

Ethical Approval: Not applicable

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Author Contributions:

The conception or design of the work: Slobodan Micović, Petar Vuković, Petar Milačić, Zoran Tabaković, Stefan Grujić

The acquisition, analysis, or interpretation of data: Ivan Soldatović, Ivana Petrović

Preparing the draft of the manuscript or interpretation of revised version of manuscript: Igor Živković, Miloš Matković

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HIRURŠKA ZAMENA AORTNE VALVULE ISTOG DANA NAKON STENTIRANJA KAROTIDNE ARTERIJE: MANJE INVAZIVNA PROCEDURA KOD VISOKORIZIČNIH PACIJENATA

Slobodan Micović[1,2], Zoran Tabaković[1], Ivan Soldatović MD[2], Petar Vuković[1,2], Petar Milačić[1,2], Ivana Petrović[1], Miloš Matković [2,3], Stefan Grujić [1], Igor Živković [1,2]

Sažetak

Uvod: Etiologija stenoze aortne valvule (SOAS) je multifaktorijalna; hipertenzija, hiperlipidemija i dijabetes melitus su najčešći faktori rizika za nastanak ovog oboljenja. Ovi faktori rizika povećavaju i učestalost ateroskleroze u perifernim arterijskim krvnim sudovima. Hemodinamski poremećaj kod oba oboljenja povećava rizik od cerebrovaskularnih događaja. Zbog preklapanja simptoma kod pacijenata sa udruženom stenozom aortne valvule i karotidnom bolešću, nije lako doneti odluku o indikaciji za adekvatnim tretmanom. Postoji nekoliko strategija lečenja: hibridna procedura, simultana hirurgija, etapna procedura, transkateterska tehnika ili medikamentozno lečenje.

Cilj: Cilj studije je ispitivanje izvodljivosti i sigurnosti hibridne procedure SAVR i CAS kod pacijenata sa udruženom aortnom stenozom i stenozom karotidnih arterija.

Materijal i metode: Prospektivna nerandomizovana studija je izvedena na našem Institutu u periodu od avgusta 2015. godine do avgusta 2023. godine i pacijenti su bili podvrgnuti hibridnoj procedure (istog dana je urađena hirurgija aortne valvule i implantacija stenta u karotidnoj arteriji).

Rezultati: Studijom je obuhvaćeno 34 pacijenta sa udruženom karotidnom bolešću i stenozom aortne valvule. Osim same hirurgije aortne valvule, u najvećem broju slučajeva pacijentima je rađena i konkomitantna hirurška revaskularizacija miokarda. Ukupno su evidentirana 3 neželjena kardiovaskularna događaja.

Zaključak: Nema mnogo istraživanja na ovu temu, te nema jasnih preporuka o strategiji lečenja. Simultano hirurško lečenje aortne valvule i karotidne arterije se izvodi uz prihvatljivo dobre rezultate, ali može biti previše invazivno za visokorizične pacijente. U tom slučaju treba razmotriti hiruršku zamenu aortnog zalistka i CAS kao manje invazivnu opciju lečenja.

Ključne reči: stentiranje karotidne arterije, stenoza aortne valvule, hirurška zamena aortne valvule

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