



Case Report

Carotid artery stenosis concomitant with severe aortic stenosis treated by combination of staged angioplasty and transcatheter aortic valve implantation: A case report

Ryosuke Shintoku¹, Mikito Hayakawa², Tomoya Hoshi³, Sho Okune⁴, Takato Hiramine⁴, Toshihide Takahashi¹, Hisayuki Hosoo¹, Yoshiro Ito¹, Aiki Marushima¹, Eiichi Ishikawa¹, Yuji Matsumaru¹

¹Department of Neurosurgery, Faculty of Medicine, University of Tsukuba, ²Division of Stroke Prevention and Treatment, Faculty of Medicine, University of Tsukuba, ³Department of Cardiology, Faculty of Medicine, University of Tsukuba, ⁴Department of Stroke and Cerebrovascular Diseases, University of Tsukuba Hospital, Tsukuba, Japan.

E-mail: Ryosuke Shintoku - rshintoku@gunma-u.ac.jp; *Mikito Hayakawa - mikito-h@jc4.so-net.ne.jp; Tomoya Hoshi - hoshi.tm@md.tsukuba.ac.jp; Sho Okune - sho.oku27@gmail.com; Takato Hiramine - hiramine.takato.bg@ms.hosp.tsukuba.ac.jp; Toshihide Takahashi - takahashi.toshihi.w@alumni.tsukuba.ac.jp; Hisayuki Hosoo - hisayuki.hosoh@gmail.com; Yoshiro Ito - yoshiro@md.tsukuba.ac.jp; Aiki Marushima - aiki.marushima@md.tsukuba.ac.jp; Eiichi Ishikawa - e-ishikawa@md.tsukuba.ac.jp; Yuji Matsumaru - yujimatsumaru@md.tsukuba.ac.jp



*Corresponding author:

Mikito Hayakawa,
Division of Stroke Prevention
and Treatment, Faculty of
Medicine, University of
Tsukuba, Tsukuba, Japan.

mikito-h@jc4.so-net.ne.jp

Received : 19 June 2022

Accepted : 16 September 2022

Published : 14 October 2022

DOI

10.25259/SNI_560_2022

Quick Response Code:



ABSTRACT

Background: When severe aortic stenosis (AS) is concomitant with carotid stenosis, carotid artery stenting (CAS) will become a high-risk procedure because baroreceptor reflex-induced bradycardia and hypotension may cause irreversible circulatory collapse. When carotid stenosis-related misery perfusion is present, the risk of cerebral hyperperfusion syndrome increases after carotid revascularization. We report a case of severe carotid disease concomitant with severe AS successfully treated by a combination of staged angioplasty (SAP) and transcatheter aortic valve implantation (TAVI).

Case Description: An 86-year-old man presented with transient deterioration of mental status and sluggish responsiveness continuous from the previous day. Magnetic resonance imaging of the brain revealed a right putaminal infarction, occlusion of the right internal carotid artery (ICA), and severe stenosis of the left ICA. Severe AS was diagnosed and single-photon emission computed tomography showed misery perfusion at the bilateral ICA territories. We performed a staged treatment consisting of SAP for the left carotid stenosis and TAVI. A first-stage carotid angioplasty was performed, followed by TAVI 2 weeks later and second-stage CAS 1 week after that. There were no apparent periprocedural complications throughout the clinical course.

Conclusion: Combining SAP and TAVI may be an effective treatment option for severe carotid stenosis with misery perfusion concomitant with severe AS.

Keywords: Carotid artery stenting, Cerebral hyperperfusion syndrome, Severe aortic stenosis, Staged angioplasty, Transcatheter aortic valve implantation

INTRODUCTION

There is currently no consensus on the treatment strategy for severe carotid artery stenosis concomitant with severe aortic stenosis (AS). Carotid artery stenting (CAS) may worsen the systemic circulatory dynamics of patients with severe AS, sometimes leading to circulatory collapse

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due to bradycardia and hypotension induced by baroreceptor reflex during the revascularization procedure.^[8] Transcatheter aortic valve implantation (TAVI) is an established treatment for elderly AS patients with multiple comorbidities and, before CAS, appears safe since concomitant carotid artery stenosis was reported to be unrelated to increase in periprocedural stroke risk.^[9] However, in patients with carotid-stenosis-related misery perfusion, the safety profile of TAVI remains unclear. Furthermore, patients with misery perfusion are known to be at high risk of developing cerebral hyperperfusion syndrome (CHS) after conventional and single-stage carotid revascularization procedures, including carotid endarterectomy and CAS.^[7] In recent years, staged angioplasty (SAP) has been reported to be effective in avoiding CHS development in such patients.^[4,17] Herein, we report a case of severe carotid artery disease with misery perfusion concomitant with severe AS treated through a combined and staged strategy consisting of SAP and TAVI.

CASE DESCRIPTION

An 86-year-old man with a history of hypertension, Type 2 diabetes mellitus, dyslipidemia, and permanent atrial fibrillation visited our hospital and presented with transient deterioration of mental status and mildly sluggish responsiveness, continuous since the previous day. At examination time, his consciousness level was almost clear, without obviously abnormal neurological findings. Diffusion-weighted magnetic resonance imaging of the brain revealed a new-onset cerebral infarction of the right putamen [Figure 1a]. MR angiography showed total occlusion of the right internal carotid artery (ICA) and severe stenosis of the left ICA at its cervical portion [Figure 1b]. T1-weighted black blood MR imaging of the neck showed a markedly bright and massive plaque at the proximal portion of the left ICA with a very high plaque/muscle ratio (3.39), suggestive of its vulnerability [Figure 1c]. Single-photon emission computed tomography (SPECT) using N-isopropyl-p-^[123I]iodoamphetamine (^{123I}-IMP) at a resting state and after an acetazolamide challenge revealed extensive declines in cerebral blood flow (CBF; 22-29 mL/100g/min) and cerebrovascular reactivity (CVR; 7-26%) within bilateral ICA territories [Figures 1d-i]. Transthoracic echocardiography to screen for cardiac diseases showed a severe narrowing of the aortic valve area (0.82 cm²) and dobutamine stress echocardiography findings were compatible with a true-severe AS. He was diagnosed with acute ischemic stroke due to total occlusion of the right ICA, asymptomatic severe stenosis of the left ICA, and a concomitant true-severe AS. We then started oral dual antiplatelet therapy (DAPT; a loading dose of 300 mg clopidogrel on admission day followed by 75 mg/day plus 200 mg/day aspirin) and intravenous anticoagulant therapy using a systemic infusion of argatroban, a direct antithrombin agent approved for acute

atherothrombotic stroke in Japan, before switching to oral anticoagulant therapy using apixaban (5 mg/day) 5 days later.

In this case, patient status under medical treatment was considered poor because of misery perfusion in the bilateral cerebral hemispheres^[16] but the periprocedural complication risk of extracranial-intracranial bypass surgery for the right cerebral hemisphere was deemed too high. In addition, endovascular revascularization for the totally occluded right ICA was considered to be at very high risk for both ischemic complications and CHS. Since increased blood flow in the leptomeningeal collaterals in the right cerebral hemisphere through the anterior communicating artery would contribute to stroke prevention,^[12] we decided to perform a revascularization procedure for the left carotid stenosis. To avoid CHS after the carotid revascularization procedure and periprocedural stroke (resulting from a pronounced CBF decrease during the TAVI procedure), we decided to undergo a staged treatment strategy consisting of SAP for the left carotid stenosis and TAVI.

Procedures

First-stage angioplasty

Under the administration of DAPT with apixaban, we performed first-stage angioplasty under local anesthesia on the 75th day after stroke onset. Because of a so-called bovine arch, we advanced a 6Fr. FUBUKI Dilator Kit (ASAHI. INTEC, Aichi, Japan) into the left common carotid artery (CCA) through a right radial artery approach [Figure 2a]. We performed four total angioplasties by Sterling balloon catheter (Boston Scientific, Natick, MA, USA), measuring 3.0 mm × 40 mm and 3.5 mm × 40 mm, because the stenotic lesion could not be sufficiently dilated under distal filter protection using the Filterwire EZ (Boston Scientific, Natick, MA, USA) [Figure 2b]. The minimal lumen diameter (MLD) was doubled from 0.3 mm to 0.6 mm [Figures 2a and c]. The opacification of territories fed by the left ICA, including the right anterior cerebral artery, became faster and clearer than on the pretreatment angiogram [Figures 2d-e]. There were no periprocedural bradycardia, hypotension, cardio-, or cerebrovascular events. SPECT using ^{123I}-IMP at a resting state on the day after the first-stage angioplasty revealed a slight increase in CBF (approximately 5–10%) in both cerebral hemispheres and no apparent hyperperfusion [Figures 3a and b].

TAVI

Fourteen days after the first-stage angioplasty, TAVI was performed through the right femoral artery approach under general anesthesia [Figure 4a]. To perform TAVI under single antiplatelet therapy, clopidogrel and apixaban administration were, respectively, stopped 3 days before, and on the day of

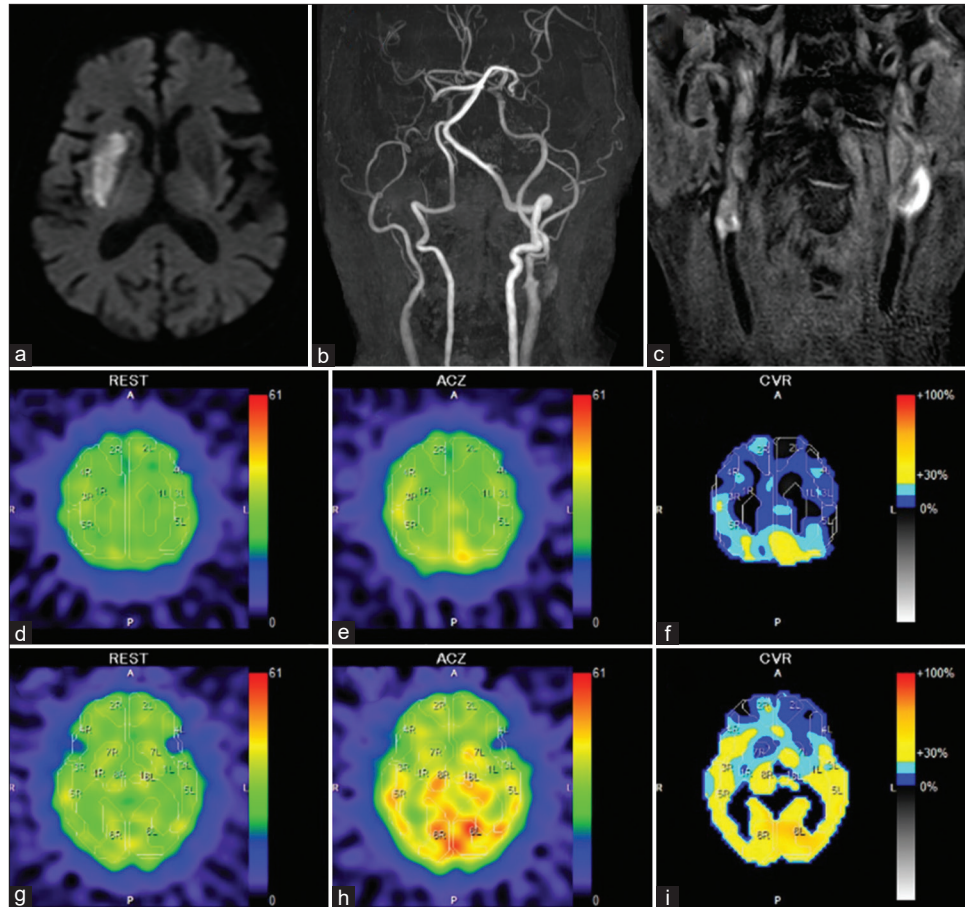


Figure 1: (a) Diffusion-weighted magnetic resonance (MR) imaging of the brain at admission showing a newly onset cerebral infarction in the right putamen. (b) MR angiography showing occlusion of the right internal carotid artery (ICA) and severe stenosis of the left ICA at its cervical portion. (c) T1- weighted black blood MR imaging at the neck showing bright signal at the cervical portion of the left ICA. The plaque/muscle ratio was 3.39. (d-i) Preprocedural single-photon emission computed tomography (SPECT) using N-isopropyl-p-(123I) iodoamphetamine (123I-IMP) at resting state (d and g), after an acetazolamide challenge (e and h), and illustrations of cerebrovascular reactivity (CVR) using a color scale (f and i). The upper row indicates the centrum semiovale level and the lower row indicates the basal ganglia level. SPECT at resting state shows a decrease in cerebral blood flow (CBF) in the bilateral cerebral hemispheres (22–29 mL/100 g/min). SPECT after an acetazolamide challenge showing an insufficient increase of CBF, illustrations of CVR showing its extensive decline (7–26%), especially in the territories of the anterior cerebral artery and the superior branch of the middle cerebral artery in the bilateral cerebral hemispheres.

TAVI (we chose a 3-day clopidogrel discontinuation period because of the risk of cerebral ischemia despite the fact that it is recommended to be at least 5 days^[15]). The patient tolerated both hypotensions during general anesthesia and rapid right ventricular pacing (maximum 180 bpm, [Figure 4b]) during valve replacement and no periprocedural cerebrovascular events occurred.

Second-stage CAS

Seven days after TAVI, we performed the second-stage CAS under local anesthesia, having resumed clopidogrel

and apixaban from the day after TAVI. We advanced a 6Fr. FUBUKI Dilator Kit into the left CCA through a right brachial artery approach. The left carotid angiogram showed no apparent restenosis in the formerly angioplastied portion [Figure 5a]. Predilatation was conducted under distal filter protection using a Sterling balloon catheter, sized 3.0 mm × 40 mm [Figure 5b]. Then, we deployed a Carotid WallStent Monorail measuring 10 mm × 31 mm (Stryker, Kalamazoo, MI, USA) and postdilatation was performed using a Sterling balloon catheter measuring 4.5 mm × 30 mm [Figures 5c-e]. Mild hypotension occurred during postdilatation and was immediately resolved after balloon deflation. No apparent

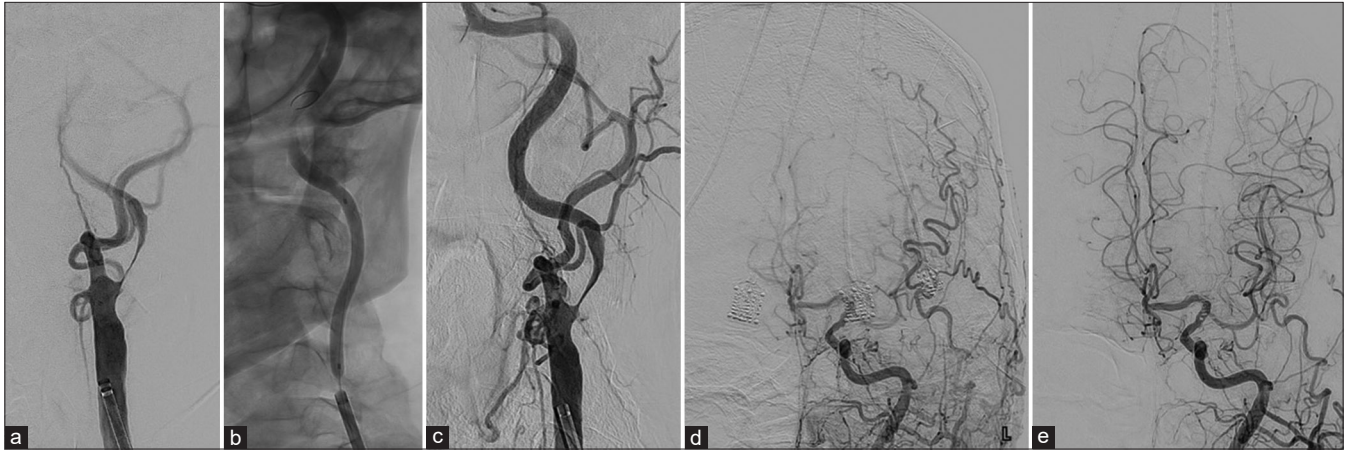


Figure 2: (a and c) Left common carotid artery angiograms at the neck level (left anterior oblique view) before (a) and after (c) the first-stage angioplasty (b): Intraprocedural fluoroscopy of the first-stage angioplasty. Severe stenosis of the left ICA at its cervical portion with delayed opacification of the portion just distal to the stenosis being improved after angioplasty. (d and e) Left common carotid artery angiograms at the intracranial level (anteroposterior views) before (d) and after (e) the first-stage angioplasty. Opacification of territories fed by the left ICA including the right anterior cerebral artery becoming faster and clearer.

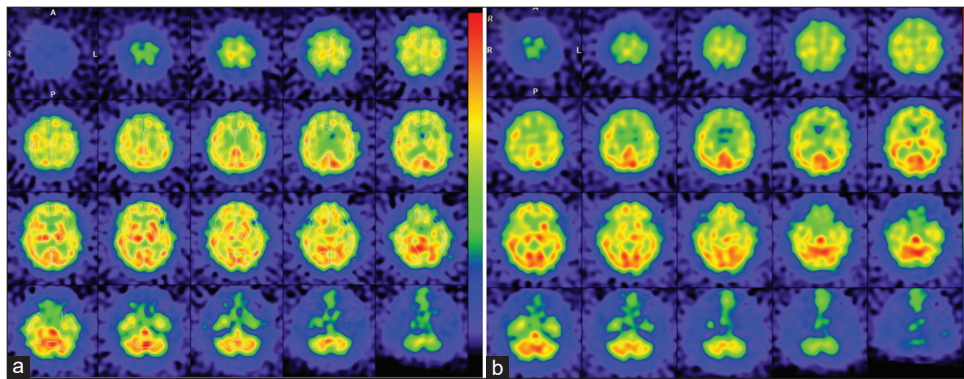


Figure 3: SPECT using ^{123}I -IMP at a resting state before (a) and on the day after the first-stage angioplasty (b) showing a slight increase in CBF (approximately 5–10%) in both cerebral hemispheres and no apparent hyperperfusion.

periprocedural complications, including ischemic stroke or CHS, were observed [Figures 5f and g]. The patient was discharged home without any newly developed neurological deficits.

DISCUSSION

We successfully treated a case of severe carotid disease with misery perfusion concomitant with severe AS by combining SAP and TAVI. To the best of our knowledge, this is the first case report of such a treatment strategy.

Optimal treatment strategies for patients with severe carotid stenosis combined with severe AS are still unclear. In general, CAS during severe AS should be avoided because of the risk of circulatory collapse and cardiac arrest due to bradycardia and hypotension.^[8] TAVI is an established treatment for elderly patients with multiple comorbidities

and its perioperative stroke rate was reported to be relatively low, at approximately 3.5% (0.6–5%).^[5] Kochar *et al.* reported that carotid stenosis was not associated with an increased risk of periprocedural stroke after TAVI.^[10] On the contrary, Thirumala *et al.* wrote that bilateral carotid disease was a significant risk factor for periprocedural stroke after TAVI with an adjusted odds ratio of 4.46 (95% confidence interval, 1.42–3.57).^[13] Hypoperfusion during rapid right ventricular pacing for TAVI procedure has been reported to be a major causal factor of stroke.^[9] These reports indicate TAVI as a high-risk procedure in patients who have bilateral severe carotid disease with misery perfusion. Although there are several reports of CAS and TAVI performed simultaneously,^[3] we considered that the periprocedural risk of stroke and CHS of the simultaneous procedure might be high in this case because CVR recovery was reported to take approximately 2 weeks after first-stage angioplasty in patients

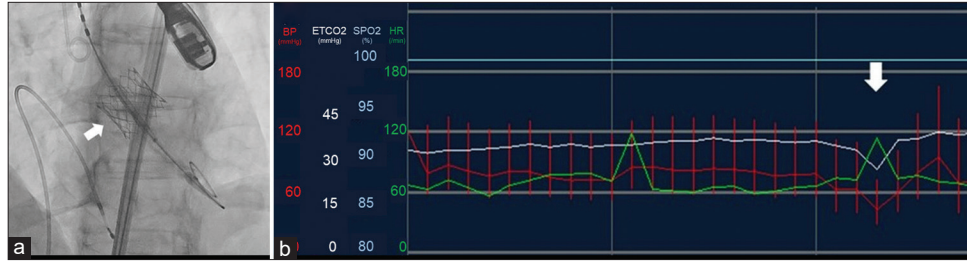


Figure 4: (a) Intraoperative fluoroscopy during transcatheter aortic valve implantation (TAVI) demonstrating the deployment of the valve device (white arrow). (b) Vital signs chart during general anesthesia for the TAVI procedure demonstrating a pronounced decrease of blood pressure during the steep increment of heart rate due to the rapid right ventricular pacing for deployment of the valve device (white arrow). The red bars and green lines represent the blood pressure and heart rate, respectively.

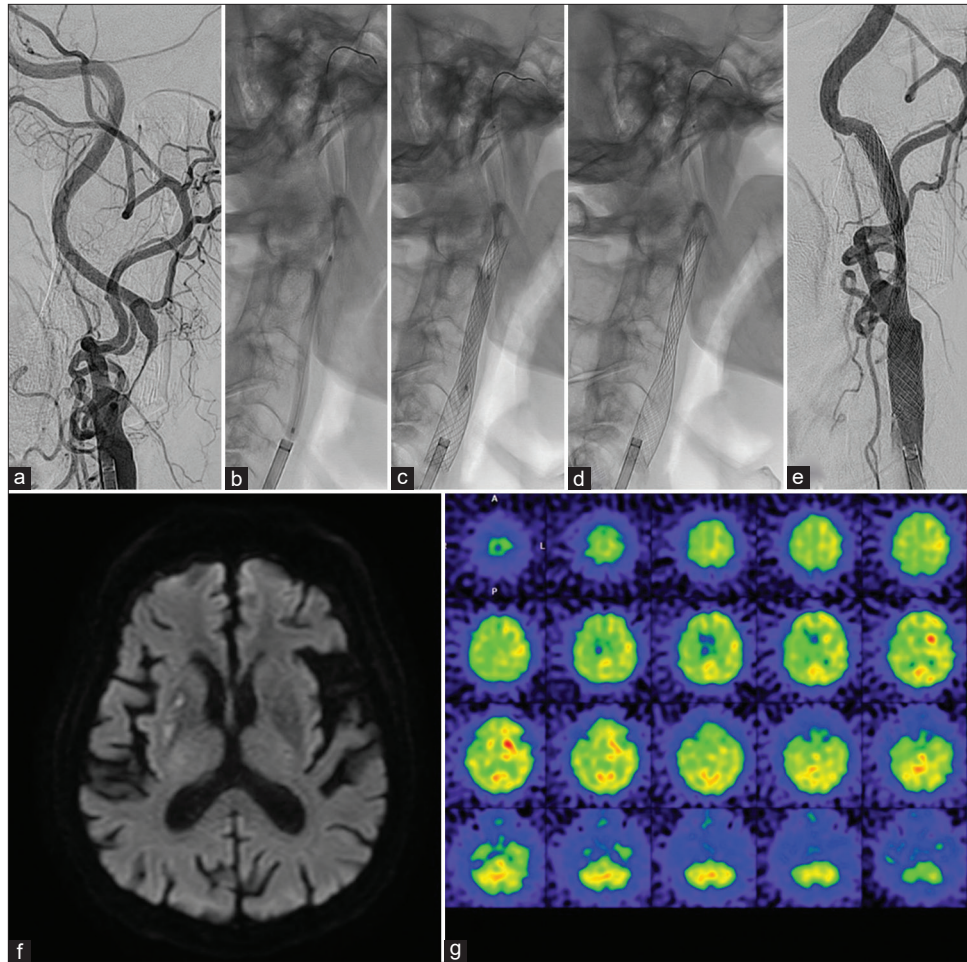


Figure 5: (a and e) Left common carotid artery angiograms at the neck level (left anterior oblique view) before (a) and after (e) the second-stage carotid artery stenting (CAS). (b-d) Intraoperative fluoroscopies during predilatation (b), postdilatation (c), and immediately after CAS procedure (d). (f) Diffusion-weighted MR imaging of the brain on the day after the second-stage CAS showing no newly onset, abnormal, and hyperintense lesion. (g) SPECT on the day after the second-stage CAS showing a mild increase (recovery) of CBF in the territories of the left anterior and middle cerebral arteries that did not meet the criteria for hyperperfusion phenomenon.

undergoing SAP.^[13] Therefore, we decided on SAP for the left carotid stenosis in combination with TAVI.

The key point in this case was the effectiveness of SAP in two ways: preserving CBF during TAVI and preventing CHS after CAS. SAP has been reported as an effective method against CHS in patients at high risk for CHS without increasing ischemic complications.^[4,17] Several definitions of high risk category for CHS using quantitative SPECT have been reported: decreases of both CBF at rest and CVR (e.g., CBF at rest <80% or asymmetry index <0.8 with a concomitant CVR<10%), a decrease of CVR alone (e.g., CVR <0%, 10% or 20%), a decrease of CBF at rest alone (e.g., CBF at rest <80% or asymmetry index <0.8),^[4] and others. In this case, ¹²³I-IMP SPECT at rest and after acetazolamide challenge showed extensive declines in CBF and CVR, suggestive of misery perfusion in the bilateral cerebral hemispheres.

Because improvement of misery perfusion was judged necessary for a safe TAVI, we prioritized first-stage angioplasty for the left carotid stenosis in our combined treatment strategy. Post-CAS bradycardia and hypotension result from carotid baroreceptor stimulation caused by balloon dilatation^[1] and are known to be more pronounced during postdilatation, which commonly uses a larger-diameter balloon catheter than predilatation.^[11] Since the first-stage angioplasty in SAP was performed by a technique equivalent to predilatation with an undersized balloon, it was considered less likely to cause bradycardia and hypotension than regular CAS. If bradycardia or hypotension had occurred during angioplasty, it would have improved immediately after deflation of the balloon. Prophylactic atropine administration and use of a temporary cardiac pacemaker would be effective.^[6] In this case, neither bradycardia, hypotension, nor cardiac complications, occurred in the periprocedural period of the first-stage angioplasty.

The target MLD in the first-stage angioplasty was considered to be 2.0 mm to avoid both CHS and ischemic complications.^[4] However, the optimal target MLD value, including the maintenance of CBF during TAVI, was still unknown. Although the stenotic site was not sufficiently dilated (0.6 mm) after the first-stage angioplasty, in this case, the affected territories were faster and more clearly opacified compared with the preprocedural angiogram. As a result, no periprocedural strokes occurred after TAVI and a smaller target lumen diameter might be acceptable when angioplasty is performed for a purpose as in this case.

To obtain and maintain the optimal MLD, additional stenting using a detachable, rolled-sheet stent (Solitaire; Covidien, Irvine, CA, USA), or a balloon-expandable coronary stent at the first stage were reported.^[2,18] However, additional deployment of a small-caliber stent during angioplasty at the first stage is hardly advisable in the present case, because interruption of DAPT during the periprocedural period of

TAVI might cause carotid in-stent thrombosis. Further study is needed to clarify the optimal MLD and methods enabling its maintenance during the periods between the first-stage angioplasty, TAVI, and second-stage CAS.

In the present case, TAVI was performed 2 weeks after the first-stage angioplasty and second-stage CAS was performed 1 week later. Uchida *et al.* showed that severely reduced CVR recovered to nearly normal values after 2 weeks.^[14] Therefore, the above-mentioned intervals were adopted as the time when CBF and CVR were restored, restenosis did not occur, and platelet aggregation was sufficiently suppressed by resuming clopidogrel again after the interruption of DAPT in the TAVI periprocedural period. Optimal intervals between SAP and TAVI should be further investigated.

CONCLUSION

The combination of SAP and TAVI may be an effective treatment option for severe carotid stenosis with misery perfusion concomitant with severe AS.

Acknowledgments

The authors would like to thank Dr. Alexander Zaboronok and Dr. Bryan J. Mathis for professional and language revision.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Shintoku R, Hayakawa M, Hoshi T, Okune S, Hiramane T, Takahashi T, *et al.* Carotid artery stenosis concomitant with severe aortic stenosis treated by combination of staged angioplasty and transcatheter aortic valve implantation: A case report. *Surg Neurol Int* 2022;13:469.