Overlapped Stenting Is Associated with Postoperative Hypotension after Carotid Artery Stenting

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Background: Hypotension (HT) is well recognized to frequently occur during and after carotid artery stenting (CAS), which sometimes causes postoperative complications such as stroke or myocardial infarction. This study aimed to examine the risk factors associated with HT after CAS based on the hypothesis that overlapped stenting may affect postoperative HT. *Methods:* A total of 106 lesions in 95 patients with carotid artery stenosis who underwent CAS were reviewed. Bradycardia and HT were defined as a heart rate and a systolic blood pressure less than 60 beats/min and 100 mm Hg, respectively. The patients were categorized by the presence (group H) or the absence (group N) of postoperative HT, respectively, and demographic data, risk factors, conditions of carotid artery stenosis, procedures, and pre- and intraoperative hemodynamics were compared between these 2 groups. Multivariate analysis was performed to evaluate independent factors associated with postoperative HT. *Results:* In total, postoperative HT was observed in 30 (28.3%) cases. The incidence of overlapped stenting, the use of an open-cell stent, and intraoperative HT were significantly higher in group H ($P = .03$, .01 and < .01, respectively). The distance from carotid bifurcation and the maximum stenotic lesion tended to be shorter in group H ($P = .09$). In the multivariate logistic regression analysis, using all these variables, the overlapped stenting and intraoperative HT were found to be independent predictors for postoperative HT. *Conclusion:* The overlapped stenting affected postoperative HT after CAS. Blood pressure should be strictly controlled in cases with overlapped stenting or intraoperative HT after CAS. **Key Words:** Carotid artery stenting—hypotension—overlapped stenting—plaque protrusion.

Introduction

Carotid artery stenting (CAS) using distal filter protection is indicated as an alternative to carotid endarterectomy (CEA) to treat symptomatic or asymptomatic stenosis of the internal carotid artery (ICA).[1-4] CAS is considered to be a less invasive procedure as well as to have a favorable successful rate for the treatment for stenosis of the ICA. However, recent studies have revealed that severe arterial hypotension (HT), bradycardia (BC), or asystole occurred twice as often in patients treated by CAS than by CEA.[5] Such a marked change in hemodynamics may lead to a temporary reduction in cerebral perfusion.[6,7] The incidence of stroke was also reported to be higher after CAS than after CEA.[2] Compared with CEA, this relatively high incidence of complications due to the postoperative hemodynamic depression cannot be ignored. Therefore, the independent predictors for such hemodynamic instability after CAS need to be clarified. Recently,

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several risk factors related with previous patient history,[8,9] conditions of carotid artery stenosis,[10-12] procedures,[12,13] and intraoperative hemodynamics[9,14,15] have been documented.

On the other hand, plaque protrusion or migration was occasionally detected during CAS by intraoperative intravascular ultrasound (IVUS)[16] or angiogram,[17] especially among cases with vulnerable plaques. Overlapped stenting may sometimes be required due to failure to compress the plaque by balloon angioplasty alone.[18] However, the influence of overlapped stenting on postoperative hemodynamic depression remains unclear. The present study aimed to examine the factors associated with HT after CAS based on the hypothesis that overlapped stenting may affect postoperative HT.

Methods

Patients

All study protocols were approved by the ethics committee of Hiroshima University. Between August 2011 and April 2015, 95 consecutive patients with stenosis of the ICA underwent 106 CAS procedures without patient selection. The average age was 71.5 ± 6.8, and 95 (89.6%) procedures were performed on men. All patients received multiple antiplatelet drugs (clopidogrel at 75 mg, aspirin at 100 mg, and cilostazol at 200 mg daily) for at least 1 week before CAS.

Procedure

All CAS procedures were performed under local anesthesia and heparin was administered to achieve an activated clotting time of more than 275 seconds during the procedure. In total, 104 (98.1%) procedures were performed by the dual protection (simultaneous flow reversal and distal filter) and blood aspiration methods as described previously.[19,20] A 9-Fr occlusion balloon-guiding catheter (OPTIMO; Tokai Medical Products, Aichi, Japan) was introduced into the common carotid artery via the femoral artery. Next, a balloon wire system (GuardWire; Medtronic, Minneapolis, MN) was introduced into the external carotid artery. The proximal end of the 9-Fr occlusion balloon-guiding catheter was connected to the 4-Fr sheath inserted into the femoral vein via the blood filter. Under flow reversal, a filter wire (FilterWire EZ; Boston Scientific, Natick, MA) was placed into the high cervical ICA. Under dual protection, predilation was performed and a self-expanding stent was deployed. The type of stent (open or closed cell) was selected based on the tortuosity of the treated ICA. The stents used in this method were the Carotid Wallstent (Boston Scientific) in 89 cases, PRECISE (Johnson & Johnson, Miami Lakes, FL) in 10 cases, and PROTÉGÉ (ev3, Inc., Plymouth, MN) in 9 cases, respectively. Postdilation was performed with an angioplasty balloon with the diameter of the distal normal ICA. An aspiration catheter (Export aspiration catheter, Medtronic) was then placed between the proximal end of the stent and the distal filter, and the blood was aspirated several times from the ICA. Subsequently, IVUS was performed to confirm the existence of plaque protrusion or migration, and if more than 1 mm of visible tissue was detected on the luminal side of the stent struts, an additional stent was overlapped to cover and compress all of the plaque completely. Argatroban (2.5 mg/h) was continued for 12 hours after CAS. Dual antiplatelet drugs were administered for 3 months and a single antiplatelet drug was prescribed indefinitely.

On the other hand, 2 (1.9%) procedures were performed via the brachial artery because it was impossible to approach the lesions via the femoral artery due to a history of abdominal aortic aneurysm, femoral-to-femoral artery bypass, or bovine arch. In these 2 cases, a 6-Fr guiding sheath (Sheathless NV; Asahi Intecc, Nagoya, Japan) was introduced and the Carotid Wallstent was deployed under only a distal filter (FilterWire) or a balloon (GuardWire) protection. The other strategies were equivalent with the methods described previously.

Definition and Management for Hemodynamic Depression

Intra- and postoperative BC and HT were defined as a heart rate and a systolic blood pressure less than 60 beats/min and 100 mm Hg, respectively. Changes in heart rate and blood pressure were measured via an electrocardiogram monitor and a sheath in the femoral artery during the procedure. Electrocardiogram monitoring was continued postoperatively and noninvasive blood pressure measurements were obtained every 15 minutes after the procedure. Before the stenting, .5 mg of atropine sulfate was administered prophylactically. In cases with intraoperative HT, 1 mg of etilefrine was administered intermittently. In cases with postoperative HT, etilefrine was infused continuously to maintain a systolic blood pressure greater than 100 mm Hg.

Statistical Analyses

All statistical analyses were performed using JMP version 10.0 (SAS Institute, Cary, NC). Values are presented as the mean ± standard deviation. Categorical variables were compared with the Fisher exact probability test. Continuous variables with normal distributions were analyzed by the Student *t*-test, and those with non-normal distributions were analyzed by the Mann–Whitney *U*-test. The patients were divided into 2 groups: those who exhibited postoperative HT (group H, n = 30) and those who did not (group N, n = 76). The patients' demographic data, risk factors, conditions of carotid artery stenosis, procedures, intraoperative hemodynamic changes, and preoperative hemodynamics were compared between subgroups, and sorted by the occurrence of postoperative