学 位 論 文 の 要 旨

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学 位 論 文 名　A Study of the Effect of Anatomic Risk Factors on Carotid Artery Stenting

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論 文 内 容 の 要 旨

INTRODUCTION

The cervical internal carotid artery (ICA) is prone to arterial stenosis caused by atherosclerosis, and when the ICA stenosis (ICS) is severe, it can cause cerebral infarction. Randomized controlled trials (RCTs) have studied the therapeutic efficacy of pharmacological versus surgical therapies to prevent stroke caused by severe ICS. In the 2000s, carotid artery stenting (CAS), a minimally invasive catheter-based treatment, was introduced. The SAPPHIRE study demonstrated the superiority of CAS over CEA for older adults and those at high risk for surgical procedures such as cardiac and respiratory disease. Since SAPPHIRE, five RCTs of CEA vs CAS (EVA-3S, SPACE, ICSS, CREST, ACT-1) have been published. These studies reported that while CAS was non-inferior to CEA, CAS resulted in more perioperative minor strokes. And two studies, SPACE and CREST, also reported a higher risk of perioperative ischemic stroke in older adults undergoing CAS. The results of these studies led to a revalidation of the usefulness of CAS for older adults as reported in the SAPPHIRE study. Anatomic risk factors have been shown to contribute to this, including severe angulation of the descending aorta and aortic arch, as well as the common carotid artery (CCA) and ICA.

Our facility is actively performing CAS as a surgical treatment for ICS in older adults because it is less invasive and can be performed under local anesthesia. In the present study, we examined how the anatomic factors of severe angulation of the aortic arch and carotid lesion

affect the outcome of CAS.

MATERIALS AND METHODS

Patients diagnosed with cervical ICS and who underwent CAS at Shimane University Hospital between January 2015 and December 2020 were included in the study. Dissected lesions, perioperative re-treatment after CAS, restenotic lesions after CAS, and CAS performed emergently were excluded. In addition, the transfemoral artery approach was included in this study; patients who underwent the procedure via the transbrachial approach were excluded.

Data collected included type of the aortic arch, bifurcation angle between CCA and ICA (CCA-ICA angle). The success or failure of CAS was also assessed by two factors: A) symptomatic ischemic stroke within 30 days of surgery and B) postoperative ischemic DWI lesions. The shape of the aortic arch was classified by the relationship between the aortic arch and brachiocephalic artery origin height using MRA or CTA, or the presence of a bovine arch. Acute angle type of aortic arch was defined as a type III for right-sided stenotic lesions, and as a type III or bovine arch for left-sided stenotic lesions. CCA-ICA angle is measured from the angiography during procedure. Postoperative MRI was used to classify the presence of postoperative ischemic DWI lesions.

Values are presented as means. Categorical variables were compared with Fisher's exact probability test. Continuous variables with normal distributions were analyzed with Student's t-test and non-normally distributed ones with Mann-Whitney U-test. P values less than 0.05 were considered to indicate statistical significance.

The study protocol was approved by the Research Ethics Committee of Shimane University.

RESULTS AND DISCUSSION

Total of 186 cases of CAS were performed. But 29 cases were excluded. The final number of cases incorporated was 157. The median age was 75 years. Forty-eight cases had an acute angle type of aortic arch (30.6%). The median CCA-ICA angle was 148°. Thirteen cases (8.3%) had angulation of 120° or less, which is considered severe. Symptomatic ischemic stroke within 30 days after surgery occurred in 15 cases (9.6%). Eighty-seven cases (55.4%) had postoperative ischemic DWI lesions.

In bivariate analysis, left-sided lesions and A) ($p = 0.028$), as well as age and B) ($p = 0.004$), were associated. On the other hand, two anatomic factors, acute angle type of aortic arch and CCA-ICA angle, did not affect two factors, A) and B).

When CAS is performed via the transfemoral approach, the acute angle of aortic arch makes it difficult to control the guiding catheter. There is also a risk of the guiding catheter

slipping while the stent is passing through the guiding catheter. At our institution, the optimal guidewire and guiding catheter were selected and used after a thorough preoperative evaluation of the access route, and it is thought that the guiding catheter was guided in a short time and with minimal stress on the vessel wall. If the preoperative CTA or MRA showed a Type III or bovine arch, Simmons type catheter was used instead of JB2 type for the inner catheter from the beginning. For the guidewire, a softer type with a diameter of 0.035 inch was usually used, but a rigid type was used only when the guiding catheter was passed through the acute angle from the aortic arch to the CCA. Preoperative planning and selection of appropriate inner catheters and guidewires may have contributed to the lack of risk factors even in cases with acute angle type of aortic arch.

Next, if the bifurcation angle between CCA and ICA is sharp, the following two surgical steps may be difficult. The first is to cross the lesion with a microguidewire or distal protection device, and the second is to guide the stent into the stenotic lesion. There is an increased risk of postoperative thrombotic complications due to thrombosis and dispersal of lesion plaques caused by difficulty in lesion crossing. Also, if the lesion angulation is severe, it is difficult to deliver the stent on appropriate position. The study showed that sharp CCA-ICA angle was not a risk factor in either postoperative symptomatic stroke complications or ischemic DWI lesions. In all cases, the stents were successfully implanted as planned preoperatively. All cases in this study used a balloon guiding catheter as a proximal embolic protection device, which prevented thrombosis by temporarily blocking blood flow in the CCA during lesion crossing. The filter device is used as a distal embolic protection device to prevent thrombosis after lesion crossing. We believe that the appropriate use of these embolic protection devices contributed to safer CAS for patients with anatomical risks. The use of open-cell stents will also have advantages to implant, even in various angulated lesions.

We also thought that the reason for the high symptomatic stroke rate of left-sided carotid artery stenting is that the left cerebral hemisphere is often the dominant hemisphere compared to the right. Regarding the association between aging and ischemic DWI lesions, we believe that this is due to age-related vascular endothelial damage and progression of atherosclerosis, which can lead to thrombosis and ischemic lesions.

CONCLUSION

In this study, acute angle type of aortic arch and acute CCA-ICA angle were not associated with symptomatic ischemic stroke within 30 days after CAS and with postoperative ischemic DWI lesions. Even in patients with anatomical factors that make stenting difficult, a safe procedure can be expected by using the appropriate catheter, guidewire, and protection device after a thorough evaluation of vascular anatomy with preoperative imaging.