Computed Tomography Angiography of Carotid Stent

Comparison of Various Self-expandable Stent in a Phantom Model

C. SAKAI, N. SAKAI, T. OKADA, T. KUROIWA, H. ISHIHARA, A. MORIZANE
T. YANO, H. KIKUCHI

Division of Neuroendovascular Therapy and Radiology,

Institute of Biomedical Research and Innovation; Minatojima-Minamimachi, Chuo-ku, Kobe, Japan

Key words: Computed tomography angiography, carotid artery stenting, stenosis

Summary

We evaluated Computed Tomography Angiography (CTA) of four different self-expandable stents in phantom model. Three stents were made of nitinol and one was made of cobalt-based alloy. Each stent placed in plastic injector, filled with diluted iodinated contrast material, and placed on a plastic case filled with saline. CTA was performed on a four-detector CT scanner (detector collimation, 0.5mm; helical pitch 3.5). Axial and longitudinal reconstructions of CT imaging were compared with the in-stent attenuation. Three nitinol stents showed few artifact, and cobalt-based alloy stent was appeared artificial narrowing. In conclusion, CTA is useful for follow-up examination after carotid artery stenting (CAS) as a less invasive evaluation method.

Introduction

Recently, stent used interventional revascularization is alternative to carotid endarterectomy^{1,2}. However, in-stent restenosis occur in 3.6-5% of cases^{3,4}, we have to follow-up the patient over 6 months after CAS procedure. Ultrasound is a most popular modality for follow-up examination of CAS⁵, however, digital subtraction angiography (DSA) is gold standard for evaluate carotid diseases⁶. Most patients are aged and regarded as high risk of conventional

diagnostic angiography for their atherosclerotic change or other vascular lesion; we need less invasive modality for follow-up angiographical examination⁷. To evaluate usefulness of CTA for follow up of CAS, we compared findings of various self-expandable stent in a phantom model.

Material and Methods

Four different stents were evaluated with CTA. Three stents were made of nitinol (S.M.A. R.T.eR, Cordis, Miami, FL; Protégé, eV3, MN, USA; Xpert, Abbott Vascular Devices, IL, USA); one was made of a cobalt-based alloy (Easy Wallstent, Boston Scientific, MA, USA). Each stent was placed in plastic injector (2.5 ml), filled with diluted iodinated contrast material (CT density, 150 H) and placed on a plastic case filled with saline. CTA was performed on a four-detector CT scanner (Aquilion; Toshiba, Japan) using a detector collimation 0.5 mm, helical pitch 3.5, a tube current of 300 mAs, and a tube voltage of 120 KeV. A field of view of 100 mm with a 512 x 512 matrix was chosen. Axial CT images and longitudinal CT reconstruction were evaluated. CT angiograms were displayed with a window width of 1200 H and window level of 400 H.

In a clinical case, CTA was performed after IV administration of 61% iopamidol using a

Figure 1 Axial and coronal view of CT images show artifacts depended on stent type. A) S.M.A.R.T.eR (Cordis), B) Protégé (eV3), C) Xpert (Abbott), D) Easy Wallstent (Boston Scientific). Cobalt-based alloy stent (D) showed more severe artifacts than nitinol stent (A-C) and end markers (A,B) show hyperdense beamlike artifacts.

volume of 100mL at a rate of 3 mL/sec. to a female patient on six months after carotid artery stenting. Axial sections were reconstructed by the curved multiplanar reformatted axial technique.

Results

In axial CT images and longitudinal reconstruction, in-stent contrast material visibility varies depends on the type of stent (figure 1). Cobalt-based alloy stent showed more severe

artifacts than nitinol stent. Nitinol stent, that has markers on its end, revealed hyperdense beamlike artifacts at the portion of markers.

Case: A 70-year-old female was found severe stenosis on her left carotid artery incidentally. We performed CAS with S.M.A.R.T.eR stent. Six months after CAS, we examined DSA and CTA to assess in-stent restenosis (figure 2). DSA showed that only thin subintimal hyperplasia in stent; we recognized there was no restenosis clearly. However, CTA showed artifi-

cial narrowing, about 70% reduction of diameter at the calcified lesion compared with actual diameter.

Discussion

In some institute, less invasive examination, like that CTA or ultra sonography (US), is performed alternative to selective angiography for preoperative assessment of carotid artery stenosis⁸. And, DSA could not show the information of the arterial wall's component⁹, CTA has advantage to assess plaque morphology in comparison with DSA or MR angiography¹⁰. Furthermore, CTA is suitable to detect thrombus and soft plaque compared with ultrasonography¹¹.

CTA of coronary artery stent and renal artery stent were considered to be adequate examination modality for determining stent patency^{12,13,14}. In additionally, usefulness of CTA after CAS was reported in particularly detec-

tion of subintimal hyperplasia and thrombus^{10,15}.

We evaluated four different stents in phantom model to confirm how artifact we could see in CTA. Nitinol stent showed few artifacts except end markers¹⁶; on the other hand, cobalt-based alloy stent showed more severe artificial narrowing. Consequently, we recognized CTA was suitable for assessment of in-stent findings in the nitinol stent. In the case of calcified lesion, CTA showed artificial narrowing, it is likely that CTA is not so useful to evaluate such lesion.

Conclusions

We could evaluate in-stent findings except for calcified lesion, CTA is a useful not only preoperative assessment of CAS but also post-operative study. Nitinol stent without end marker showed minimal artifact.

References

- 1 Coward LJ, Featherstone RL, Brown MM: Safety and efficacy of endovascular treatment of carotid artery stenosis compared with carotid endarterectomy: a Cochrane systematic review of the randomized evidence. *Stroke* 36: 905-911, 2005.
- 2 Qureshi AI, Kirmani JF et Al: Carotid angioplasty with or without stent placement versus carotid endarterectomy for treatment of carotid stenosis: a meta-analysis. *Neurosurgery* 56: 1171-1179, 2005.
- 3 Setacci C, de Donato G et Al: In-stent restenosis after carotid angioplasty and stenting: a challenge for the vascular surgeon. *Eur J Vasc Endovasc Surg* 29: 601-607, 2005.
- 4 Levy EI, Hanel RA et Al: Frequency and management of recurrent stenosis after carotid artery stent implantation. *J Neurosurg* 102: 29-37, 2005.
- 5 Christiaans MH, Ernst JM et Al: Antonius Carotid Endarterectomy, Angioplasty, and Stenting Study Group: Restenosis after carotid angioplasty and stenting: a follow-up study with duplex ultrasonography. *Eur J Vasc Endovasc Surg* 26: 141-144, 2003.
- 6 Streifler JY, Eliasziw M et Al: Angiographic detection of carotid plaque ulceration. Comparison with surgical observations in a multicenter study. *North American Symptomatic Carotid Endarterectomy Trial*. *Stroke* 25: 1130-1132, 1994.
- 7 Leclerc X, Gauvrit JY, Pruvo JP: Usefulness of CT angiography with volume rendering after carotid angioplasty and stenting. *Am J Roentgenol* 174: 820-822, 2000.
- 8 Logason K, Karacagil S et Al: Carotid artery endarterectomy solely based on duplex scan findings. *Vasc Endovascular Surg* 36: 9-15, 2002.
- 9 Cinat ME, Pham H et Al: Improved imaging of carotid artery bifurcation using helical computed tomographic angiography. *Ann Vasc Surg* 13: 178-183, 1999.
- 10 Oliver TB, Lammie GA et Al: Atherosclerotic plaque at the carotid bifurcation: CT angiographic appearance with histopathologic correlation. *Am J Neuroradiol* 20: 89-901, 1999.
- 11 Harada K, Nakahara I et Al: Comparison of the findings of multislice CT and angiography after stenting for supraaortic arteries. *No Shinkei Geka* 32: 29-35, 2004.
- 12 Hong C, Chrysant GS et Al: Coronary artery stent patency assessed with in-stent contrast enhancement measured at multi-detector row CT angiography: initial experience. *Radiology* 233: 286-291, 2004.
- 13 Behar JV, Nelson RC et Al: Thin-section multidetector CT angiography of renal artery stents. *Am J Roentgenol* 178: 1155-1159, 2002.
- 14 Mallouhi A, Rieger M et Al: Volume-rendered multi-detector CT angiography: noninvasive follow-up of patients treated with renal artery stents. *Am J Roentgenol* 180: 233-239, 2003.
- 15 Cademartiri F, Mollet N et Al: Images in cardiovascular medicine. Neointimal hyperplasia in carotid stent detected with multislice computed tomography. *Circulation* 108: e147, 2003.
- 16 Letourneau-Guillon L, Soulez G et Al: CT and MR imaging of nitinol stents with radiopaque distal markers. *J Vasc Interv Radiol* 15: 615-624, 2004.

Chiaki Sakai, M.D.
Division of Neuroendovascular Therapy
and Radiology
Institute of Biomedical Research and Innovation
Minatojima-Minamimachi 2-2
Chuo-ku, Kobe
650-0047 Japan