Computerized Assessment of Carotid Plaque Echogenicity before Stenting

H. TAKAHATA, K. HAYASHI*, N. KITAGAWA*, M. KAMINOGO*, H. KOGA, S. SHIBATA*

Department of Neurosurgery, Sasebo City General Hospital, Nagasaki; Japan

*Department of Neurosurgery, Nagasaki University School of Medicine, Nagasaki; Japan

Key words: carotid arteries, ultrasound, stents

Summary

To assess the ability of transcutaneous ultrasound (US) to identify carotid atherosclerotic plaques at high risk for development of procedural strokes, the authors retrospectively analyzed the plaque echomorphology by means of gray-scale value (GSV). Both transcutaneous and intravascular US demonstrated a similar ability to characterize the atherosclerotic plaques.

A case with embolic complication was proven to have had the lowest GSV in the studied cases.

With computerized assessment of plaque echogenicity, pre-procedural transcutaneous US may be used to predict plaques that are associated with a high risk of distal embolization.

Introduction

Carotid plaques are usually characterized by transcutaneous ultrasound (US). Although it is a simple and noninvasive technique, the significance of transcutaneous US before carotid stenting has not been sufficiently assessed. The purpose of this study is to evaluate the reliability of pre-procedural transcutaneous US for the assessment of carotid plaque echomorphology on the basis of computerized analysis of the plaque echogenicity.

Methods

Both transcutaneous and intravascular US were performed pre-procedurally in 5 patients with severe carotid stenosis who underwent carotid stenting (table). For the transcutaneous US examination, all patients had their carotid artery scanned with a 7.5-MHz linear array probe (Aloka). The transverse color Doppler images were stored on super-VHS videotape. For the intravascular us (IVUS) examination, a patient was catheterized with an 8 Fr guide catheter (brite tip, J & J Cordis) under local anesthesia and a transducer of an IVUS (Endosonics) was inserted to the distal internal carotid artery. Then, the transducer was slowly pulled to proximal and the images were stored on s-VHS videotape. Subsequent to the IVUS examination, the patient underwent stenting. The most stenotic image was captured and digitized with Media 100 (Media 100). The plaque was outlined and the gray-scale value (GSV) of each pixel in the region was measured by NIH image 1.56 (figure 2,3). The mean GSV of the plaque was adjusted by that of the adventitia for normalization.

Results

The adjusted gray-scale value of IVUS ranged from 1.3 to 2.7, while that of transcuta-

Table 1 Patient characteristics

Case	age	sex	lesion	clinical features
1	71	male	Lt. ICA	re-stenosis after angioplasty
2	64	male	Lt. ICA	RIND
3	65	male	Rt. ICA	frequent TIA
4	75	male	Rt. ICA	loss of consciousness
5	76	male	Lt. ICA	loss of consciousness

Figure 1 Transverse view of an intermediate plaque. A) Transcutaneous ultrasound (US). Gray-scale value (GSV) =2.2. B) Intravascular ultrasound (IVUS). GSV =1.7.

Figure 2 Computerized analysis of the plaque echogenicity by NIH image 1.56.

neous US ranged from 1.4 to 2.6. A good correlation between the two measures was observed ($Y=0.261 + 0.989X$; $R^2=0.904$, $p=0.0131$, figure 3).

Illustrative case

A 76-year-old man underwent carotid stenting for the left carotid stenosis. The lesion was sufficiently dilated using Palmaz balloon expandable stent (J & J cordis, figure 4). However, soon after the stent placement, the patient became aphasic and hemiparesic. Diffusion weighted magnetic resonance image revealed multiple high-intensity lesions in the left cerebral hemisphere due to microembolism (figure 5). A retrospective analysis of the plaque echogenicity manifested the lowest GSV in all the patients (figure 6 and also shown as a closed circle in the figure 3).

Discussion

IVUS is now widely used in coronary arteries for guiding complex endovascular interventions^{1,2}. With an advantages that enables a direct visualization of the vessel wall, the technique is considered to be the standard of reference for imaging arterial wall and atherosclerotic plaque. IVUS seems to be feasible and safe for imaging carotid arteries with mild atherosclerotic changes³ and that are protected with a stent⁴. However, IVUS is an invasive technique that cannot be always used to image severely diseased carotid arteries because of the risk of distal embolization. Thus, there is a need for a safe and noninvasive technique for monitoring carotid plaques quantitatively before stenting.

Major concern about the US has been the classification for the plaque morphology. The

Figure 3 A good correlation was observed between the two measures (IVUS and transcutaneous US). A closed circle indicates a case with distal embolization.

existing classifications were subjective and qualitative and, therefore, the need for a standardized and quantitative method of assessment has been emphasized. In recent years, several investigators have suggested computerized assessment of carotid plaque echogenicity by means of GSV to overcome the subjectivity⁵⁻⁷.

Recognition of the imaging features that correspond to the histopathologic constituents of carotid plaques associated with increased risk of distal embolization during stenting would be useful deciding on the therapy in individual cases. Ohki et al found an increased risk of distal embolization in lesions that were echo-lucent at transcutaneous US and "soft" at histopathologic analysis in ex vivo model⁸. Despite small numbers of the cases, our results in living humans accorded with their findings. With a computerized method to evaluate the plaque morphology, pre-procedural transcutaneous US may objectively predict the plaques that are associated with a high risk of distal embolization.

Conclusion

Echomorphology of carotid plaque was retrospectively assessed by computerized gray scale method in cases of carotid stenting. Both transcutaneous and intravascular US demonstrated the similar ability to characterize carotid plaques. A case with embolic complication was proven to have had very low GSV.

Figure 4 Pre-procedural (A) and post-procedural (B) left carotid angiogram in case 5.

Figure 5 Diffusion-weighted magnetic resonance image 2 hours after stenting. High-intensity signals in the left cerebral hemisphere are indicative of distal embolization.

Figure 6 Transverse view of the left carotid artery in case 5. A) Transcutaneous US. GSV =1.4. B) IVUS. GSV =1.3.

These results suggest that the pre-procedural transcutaneous US is useful to identify carotid plaques at high risk for development of procedural strokes. Computerized assessment of the carotid plaque echogenicity may improve the criteria in patient selection for carotid stenting.

References

- 1 Cantor WJ, Peterson ED et Al: Provisional stenting strategies: systematic overview and implications for clinical decision-making. *J Am Coll Cardiol* 36: 1142-1151, 2000.
- 2 Nissen SE, Yock P: Intravascular ultrasound: novel pathophysiological insights and current clinical applications. *Circulation* 103: 604-616, 2001.
- 3 Manninen HI, Rasanen H et Al: Human carotid arteries: correlation of intravascular US with angiographic and histopathologic findings. *Radiology* 206: 65-74, 1998.
- 4 Reid DB, Diethrich EB et Al: Intravascular ultrasound assessment in carotid interventions. *J Endovasc Surg* 3: 203-210, 1996.
- 5 Aly S, Bishop CC: An objective characterization of atherosclerotic lesion: an alternative method to identify unstable plaque. *Stroke* 31: 1921-1924, 2000.
- 6 El-Barghouty NM, Levine T et Al: Histological verification of computerised carotid plaque characterisation. *Eur J Vasc Endovasc Surg* 11: 414-416, 1996.
- 7 Sabetai MM, Tegos TJ et Al: Reproducibility of computer-quantified carotid plaque echogenicity: can we overcome the subjectivity? *Stroke* 31: 2189-2196, 2000.
- 8 Ohki T, Marin ML et Al: Ex vivo human carotid artery bifurcation stenting: correlation of lesion characteristics with embolic potential. *J Vasc Surg* 27: 463-471, 1998.

Hideaki Takahata, M.D.
Department of Neurosurgery,
Sasebo City
General Hospital, 9-3 Hirase-cho, Sasebo,
Nagasaki, Japan 857-0056