Original Article

Diagnosis of Embolic Signals Detected by Conventional Transcranial Doppler Ultrasonography in Cases of Cerebral Embolism

Hidemasa NAGAI1, Seiichi ANDO1, Mikio TAKAYA2, Kouzo MORITAKE2

1 Department of Neurosurgery, Unnan General Hospital
2 Department of Neurosurgery, Shimane Medical University

The embolic signals detected by transcranial Doppler ultrasonography (TCD) are characterized as high-intensity transient signals (HITS). Two types of TCD devices, conventional and embolus-oriented, are currently used. HITS demonstrated by an embolus-oriented TCD device correspond almost specifically to embolic signals. However, the characteristics of HITS in conventional TCD and their specificity to embolic signals remain to be studied. In this study, 10 ischemic patients were examined using a conventional TCD device. Six of these patients showed HITS. In all cases, these were partly unidirectional and partly bidirectional with a unilateral tendency, and the HITS were accompanied by chirping sounds. Since the chirping sounds had the typical characteristics of embolus origin which we had revealed experimentally, the HITS were interpreted to originate from moving emboli. We conclude that HITS with chirping sounds can be regarded as embolic signals in conventional TCD, irrespective of whether they are unidirectional or bidirectional with a unilateral tendency.

Key words: cerebral embolism, embolic signals, HITS, transcranial Doppler

Introduction

Transcranial Doppler ultrasonography (TCD) has made remarkable technological progress both in terms of its mechanical structure and the computer software used. This has enabled moving cerebral emboli to be detected as embolic signals. Since TCD is portable, and can noninvasively detect embolic signals in real time, its application to cerebral infarction is a topic of current interest. Transcranial Doppler devices can detect high-intensity signals (HITS) as embolic signals, the criteria of HITS having recently been defined by the Consensus Committee of 1995. At the present time, two types of TCD apparatuses, embolus-oriented and conventional, are used clinically. The embolus-oriented TCD can detect almost specifically HITS as embolic signals on a graded color or gray scale. In contrast, the characteristics of HITS in conventional TCD, which is multipurpose in function and has been established longer, have not yet been completely clarified. Furthermore, it remains to be resolved whether HITS in conventional TCD specifically correspond to embolic signals.

In the present study, we studied the ultrasonological characteristics of HITS in conventional TCD, and tried to establish criteria for embolic signals detected by a conventional TCD device, since this type of device is far more widely utilized in routine clinical fields than embolus-oriented TCD.

Materials and Methods

We examined 10 ischemic patients with a conventional TCD instrument (TC2-64®, EME, Germany) between November 1995 and May 1996. The study group comprised 7 men and 3 women, ranging in age from 50 to 76 years (mean, 67 yr). Five patients had symptoms related to cerebral embolism. The other 5 had asymptomatic lacunar infarction demonstrated by magnetic resonance (MR) imaging. Magnetic resonance angiography revealed that these 5 asymptomatic
patients had major artery stenosis or occlusion, and aspirin was administered to all of them to prevent new infarction. The definition of HITS used in the present study was based on the criteria recognized by the Consensus Committee of 1995: (1) high-amplitude Doppler sonogram, (2) a transient high-pitched signal of very short duration, and (3) random signals. All patients were monitored for over 30 min under steady-flow conditions to exclude the influence of artifacts.

Supplementarily, an embolus-oriented TCD instrument (TC2020, EME, Germany) was used on 3 of the 5 asymptomatic patients.

Results

Patient profiles and the results of TCD are presented in Table 1.

**Symptomatic cases (5 patients):** Cerebral infarction in 5 symptomatic patients was diagnosed clinically from recent embolic events. With the conventional TCD device, chirping sounds were heard in all of the 5 symptomatic patients. HITS were also detected in all of them. In all 5 cases, the HITS were partly unidirectional and partly bidirectional with a unilateral tendency. A typical case in this group is reported below as Case 1.

**Asymptomatic cases (5 patients):** Four cases were examined using the conventional TCD device only after the beginning of aspirin administration. HITS were not detected in these patients. In one patient, TCD examination was performed before and after aspirin administration. HITS, diagnosed on the basis of the accompanying chirping sounds, were demonstrated in the pre-medication phase. The HITS were partly unidirectional and partly bidirectional with a unilateral tendency. However, HITS could not be detected after the start of aspirin administration. This case is reported below as Case 6.

Case 1: A 71-year-old male suffered from left cerebellar infarction. This patient had a serpentine and ectatic aneurysm of the basilar artery (Fig. 1). Since HITS were detected at a depth of 60 mm by the conventional TCD device applied suboccipitally, the infarction was considered to have been induced by emboli originating from the aneurysm (Fig. 2).

Case 6: MR images, taken to clarify the etiology of a headache, revealed that a 71-year-old male asymptotically had multiple lacunar infarctions in the left cerebral hemisphere (Fig. 3). Furthermore, MR angiography showed occlusion of the left internal carotid artery. HITS were detected on the left middle cerebral artery by the conventional TCD device (Fig. 4). The appearance of HITS indicated recurrence of the infarction, and aspirin administration was begun to prevent new infarction. Two months later, HITS were not detected by an embolus-oriented TCD device (Fig. 5).

![Fig. 1 CT scans in case 1](image-url)  
Computed tomography scan obtained on the day of onset (left) and two days after onset (right). Both demonstrate ectasia of the basilar artery. The CT scan taken two days after onset shows a left cerebellar infarction.

| Table 1 Patient profiles and the results of TCD |
|---|---|---|---|---|---|
| Case | Age | Sex | Stroke | conventional TCD | MRA | Diagnosis |
| 1 | 71 M | S | + | B | R | Basilar aneurysm | Cerebral Inf |
| 2 | 76 M | S | + | U/B | normal | R | R | Pons Inf, Heart disease |
| 3 | 50 M | S | + | U | normal | R | R | M1, M2 |
| 4 | 53 M | S | + | U/B | R | MCA st, R | PCA occi | L, temporal lobe inf |
| 5 | 70 M | S | + | U/B | R | MCA st | R | R | M1, M2 |
| 6 | 71 M | A | + | U | L | IC occi, L | PCA st | M1, M2 |
| 7 | 71 F | A | + | U | L | MCA st | M1, M2 |
| 8 | 67 M | A | + | U | R | MCA st | M1, M2 |
| 9 | 68 M | A | + | U | R | MCA st | M1, M2 |
| 10 | 76 M | A | + | U | L | MCA st | M1, M2 |

Fig. 2 Conventional TCD in case 1
Bidirectional signals with a one-sided tendency were detected via the suboccipital approach.

Fig. 3 Magnetic resonance (MR) images in case 6
A T1-weighted MR image (left) reveals multiple low-intensity spots in the left cerebral hemisphere. A T2-weighted MR image (middle) shows multiple high-intensity spots at the same locations. MR angiography (right) reveals absence of flow in the left internal carotid artery.

Discussion

Spencer et al.\(^9,12,13\) characterized embolic signals as random in occurrence, short, transient, unidirectional (single direction), and strong. Russell et al.\(^10,11\) used a color display in TCD, and reported almost the same characteristics of the embolic signals as those revealed by Spencer et al. It is generally known that one or more unidirectional embolic signals are displayed on background Doppler signals which reflect the movement of normal red blood cells. This phenomenon is thought to indicate that embolic particles moving along the bloodstream are detectable only in the direction of blood flow. However, some authors\(^8,13,14\) have reported that embolic signals can be detected as bidirectional signals with a unilateral tendency. This is said to be attributable to the reflection of sound caused by electronic overload. We have previously similar results using a conventional TCD device\(^7\).

In the present study, HITS that satisfied the Consensus Committee's criteria\(^1\) were always identified together with chirping sounds using a conventional TCD unit. Our previous study had revealed that, with the use of a conventional TCD device, the chirping sounds which accompany embolus-originated HITS have the following characteristics: (1) sparrow-like twittering like sounds such as "pyupyu" or "hyuhyu", (2) short and high modulated sounds which can be distinguished from the signal form a background Doppler sound. The chirping sounds in the present study fulfilled these criteria. The HITS in the present study, whether unidirectional or bidirectional with a unilateral tendency, were diagnosed as embolic signals, since all of them were accompanied by chirping sounds as described above. The present results show that the chirping sounds are a very reliable diagnostic feature by which a conventional TCD unit can detect HITS. On the basis of our present and previous studies\(^7\), we
draw the following two conclusions about HITS, which satisfy the Consensus Committee’s criteria\textsuperscript{2}, observed by conventional TCD. First, unidirectional HITS in conventional TCD can be unconditionally diagnosed as embolic signals. Second, bidirectional HITS in conventional TCD can be interpreted as embolic signals if they show a unilateral tendency and have chirping sounds.

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