

# Cerebral Infarction Due to Aortic Mural Thrombus in a Non-atherosclerotic Ascending Aorta, Detected by Cardiac CT

Ryuichi NODA,<sup>1,2</sup> Yuta TAMAI,<sup>1</sup> Masato INOUE,<sup>1</sup> and Tetsuo HARA<sup>1</sup>

<sup>1</sup>*Department of Neurosurgery, Center Hospital of the National Center for Global Health and Medicine, Tokyo, Japan*

<sup>2</sup>*Department of Neurosurgery, NTT Medical Center, Tokyo, Japan*

## Abstract

**Aortic mural thrombus (AMT) in the ascending aorta is a rare source of embolism. Recently, the usefulness of contrast computed tomography (CT) has been reported, and we sought to examine the differences between cardiac CT and CT angiography (CTA). A 58-year-old patient of acute embolic infarction was treated by endovascular thrombectomy. Postoperative cardiac CT revealed the AMT as an embolic source. The lesion was not detected by the CTA performed 2 days before. This is the first case report of AMT to highlight the apparent utility of cardiac CT. Although trans-esophageal echocardiogram (TEE) is still the first choice for routine embolic exploration, cardiac CT may play a role as an alternative tool aimed to detect small size AMT.**

Keywords: aortic mural thrombus, aortogenic infarction, cardiac CT, trans-esophageal echocardiogram, CT angiography

## Introduction

Since primary thrombosis of the aorta was first described in the late 1940s,<sup>1)</sup> it has always been a differential diagnosis for embolic stroke. Nevertheless, the possibility of missing a cryptogenic cardiac embolism has persisted because of the insufficient imaging techniques. Aortic mural thrombus (AMT) of a non-aneurysmatic and non-atherosclerotic aorta is an unusual but possible cause of embolism.<sup>2,3)</sup> Owing to the widespread use of trans-esophageal echocardiogram (TEE), routine exploration after embolic events has revealed the source of embolism. TEE is also effective for the detection of arterial septal defect (ASD), patent foramen ovale (PFO), and left atrial (LA) thrombus. Therefore, in current clinical practice, TEE is regarded as the first choice examination for patients with acute stroke of suspected aortic etiology. On the other hand, given the drawbacks that discourage the use of this

examination, an ancillary, or even alternative, examination has been sought by several clinicians, and both computed tomography angiography (CTA) and ECG-gated contrast computed tomography (cardiac CT) have been considered to play an auxiliary role in ischemic stroke management.

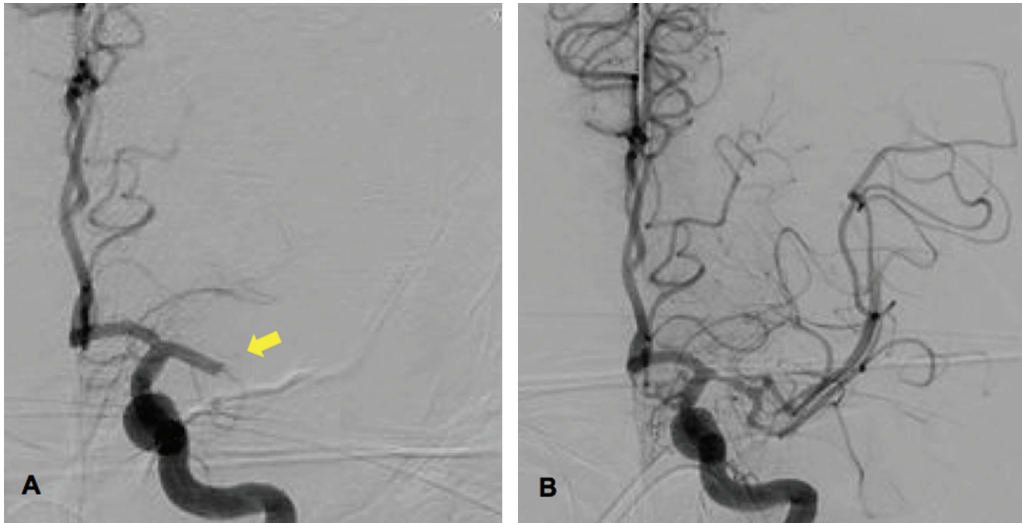
Therefore, we successfully detected a rare embolic source by TEE and compared the radiological features between CTA and cardiac CT. This is the first report to compare the radiological features between CTA and cardiac CT in AMT of the ascending aorta. Our report implies the possibility of an alternative modality of embolic source exploration.

## Case Report

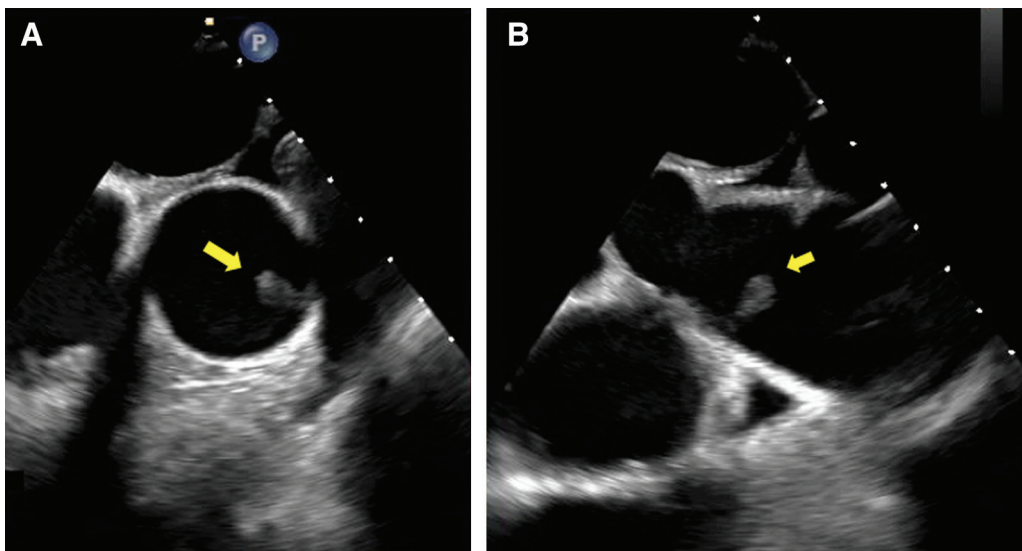
A 58-year-old patient with no medical history was brought to our emergency department with sudden onset of deterioration of consciousness. Physical examination revealed right paresis and global aphasia. The National Institutes of Health Stroke Scale (NIHSS) score was 13 out of 42. CTA and magnetic resonance imaging (MRI) images showed acute cerebral infarction due to left middle cerebral artery (MCA) occlusion. Endovascular thrombectomy was performed and subsequent imaging showed successful

Received August 21, 2020; Accepted October 26, 2020

Copyright© 2021 by The Japan Neurosurgical Society This work is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives International License.



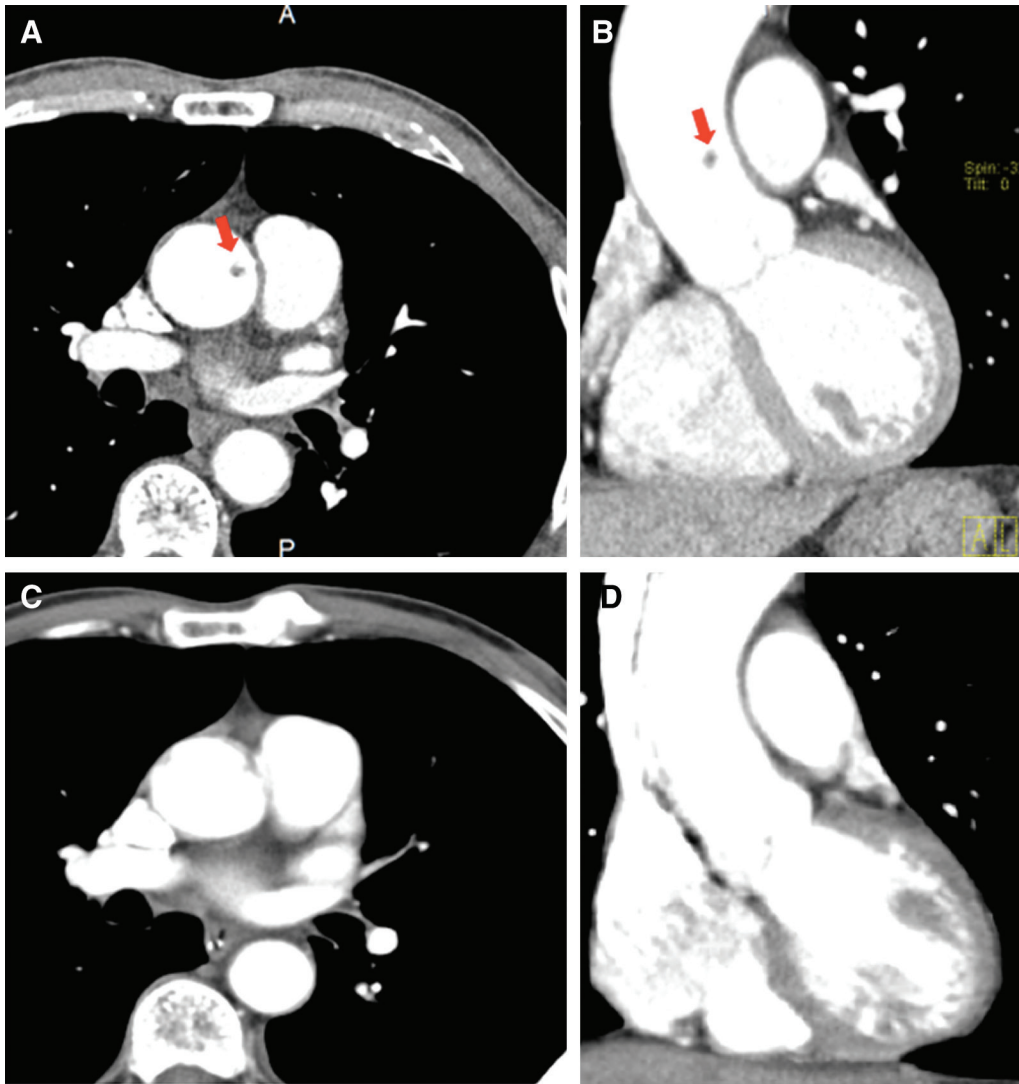
**Fig. 1** Angiographic findings of the left internal cerebral artery. MCA occlusion was shown (A, arrow). Image after thrombectomy showed revascularization of the occluded artery (B). MCA: middle cerebral artery.



**Fig. 2** TEE revealed a pedunculate tumor-like lesion approximately 7 mm in size (A, short axis view, arrow), the thrombus was highly mobile and located on the proximal ascending aorta (B, long axis view, arrow). TEE: trans-esophageal echocardiogram.

revascularization (Fig. 1). Postoperative MRI showed diffuse infarction of the left hemisphere. Since the embolic source was unknown, the patient was kept under 24-hour monitor surveillance, had a Holter electrocardiogram (ECG), and underwent transthoracic echocardiogram, but no cardiogenic embolic source was revealed. The entire aorta was normal and showed no atherosclerotic change on CTA imaging. TEE revealed a pedunculate tumor-like lesion on the proximal ascending aorta (Fig. 2). The lesion was highly mobile and approximately 7 mm in size. Cardiac CT showed a corresponding contrast

medium filling defect (Fig. 3). This finding was not detected on the CTA taken 2 days before. AMT was suspected, and surgical removal was planned 1 month after hospitalization. We started anti-coagulant therapy with heparin followed by bridging therapy with warfarin (controlled within 2.0–3.0 international normalized ratio). Follow-up TEE was performed 3 weeks after admission, and showed complete resolution of the thrombus (Fig. 4). During this period, there was no sign of symptomatic embolism. Cardiac CT was also performed and revealed the same result. An additional CTA was



**Fig. 3** Cardiac CT images showed a corresponding contrast medium filling defect on the ascending aorta. The aorta itself did not show atherosclerotic changes (A, short axis view, arrow; B long axis view, arrow). CTA images taken 2 days before cardiac CT were not able to detect the lesion (C, short axis view; D, long axis view). CT: computed tomography, CTA: CT angiography.

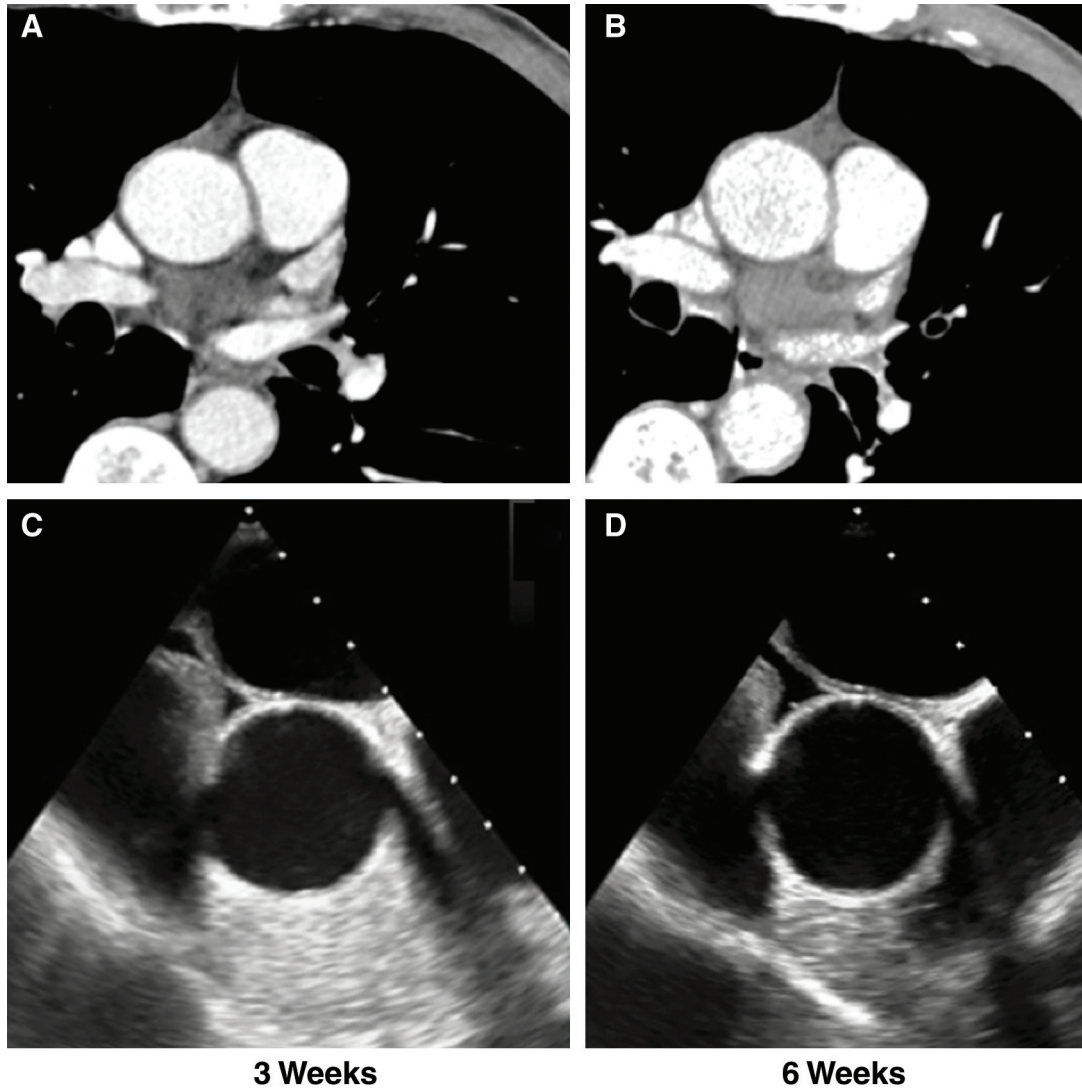
performed to rule out peripheral embolism, but there were no signs of occluded arteries. Based on the radiological and histological results and the clinical course, the final diagnosis was AMT. The operation was suspended and the patient was kept on anticoagulants. He had no recurrent lesion on TEE or cardiac CT at the 6-week follow-up (Fig. 4) and was transferred to a rehabilitation hospital.

### Discussion

Primary thrombosis of the aorta has always been a differential diagnosis of embolic stroke, but the possibility of missing a cryptogenic cardiac embolism due to insufficient imaging techniques has

been a continual problem. In 2014, Hart et al. proposed the definition of an embolic stroke of undetermined source (ESUS). In ESUS management, the search for an aortogenic source by TEE, CTA, or cardiac CT is not required.<sup>4)</sup> However, our case suggests that cardiac CT should be incorporated into the routine embolic evaluation after stroke.

The currently widespread use of TEE and the technical improvement in CT have enabled more detailed evaluation of the aorta. It is now known that there are two types of embolic sources in the aorta. The type seen in the elderly is severe complex aortic atheroma (CAA), which is defined by plaques with a thickness of greater than 4 mm or that contain mobile components or ulceration. The other type is



**Fig. 4** Follow-up cardiac CT images and TEE at 3 weeks post-stroke showed complete resolution of the aortic thrombus (A, cardiac CT; C, TEE). There was no recurrent thrombus in the follow-up images at 6 weeks post-stroke (B, cardiac CT; D, TEE). CT: computed tomography, TEE: trans-esophageal echocardiogram.

AMT of a non-aneurysmatic and non-atherosclerotic aorta, which is an unusual but possible cause of embolism. In a report of 10671 consecutive autopsy studies, 48 cases (0.45%) had thrombi with a normal aorta. Thoracic AMT was found in only 10 cases (0.09%).<sup>5)</sup> In a report of TEE performed in 27, 855 cases of recent arterial embolism, 23 cases (0.08%) had mobile aortic thrombi of the arch without atherosclerotic change.<sup>6)</sup> The latter can be easily overlooked since the aorta seems to be normal on CTA images.

In the early 2000s, the technological advancement of diagnostic images increased the detection of aortic lesions.<sup>7,8)</sup> CT has a strong advantage in evaluating extracardiac anatomy, and determining the extent of lesion. It is also valuable for patients who cannot tolerate TEE and is useful for follow-up examination.

The strongest advantage of CTA is that the aortic image can be obtained at stroke onset by extending the scan range of the cerebral CTA to include the heart, without a significant increase in the contrast medium or radiation exposure. Since CTA of the cervical and intracranial arteries has become one of the routine examinations for decision-making in acute ischemic stroke, it is feasible to make a slight change to the imaging protocol. This may resolve the potential problem of remnant clots dissolving or being flushed into the blood circulation shortly after stroke onset, before further examination can be performed.<sup>9)</sup> Yagyu et al.<sup>10)</sup> reported two cases of ascending aortic thrombus detected by CTA. However, a previous report on 250 patients showed that the sensitivity of CTA in detecting aortic arch atheroma



was 53% and the specificity was 89%, indicating that CTA may not be sensitive enough.<sup>11)</sup>

Currently, in light of advances in multi-detector CT with ECG synchronization techniques, cardiac CT enables a quick evaluation of the cardiac structure and abnormalities such as cardiogenic embolism, and complex plaques of the thoracic aorta. After detection of ECG, the scan covers the whole heart during multiple cardiac cycles. Therefore, information from different phases of the cardiac cycle is gained and can be used to construct a detailed cardiac image. Since the movement artifacts are reduced, the image quality is higher than that of CTA. Cardiac CT is already known to be a useful examination for LA thrombus detection. In a meta-analysis of 19 studies with 2955 patients with cardiogenic ischemic stroke, the efficacy of cardiac CT was confirmed with a sensitivity and specificity of 96% and 92%, respectively, for LA thrombus detection.<sup>12)</sup> Furthermore, an investigation of 46 cryptogenic stroke patients found that all 9 cases of aortic lesions detected with TEE were properly identified with cardiac CT. Indeed, Pandya et al.<sup>13)</sup> reported that cardiac CT could be used to detect CAAs with good reliability. The greatest advantage cardiac CT is that, unlike TEE, the examination is non-dependent to the examiner. In our case, cardiac CT was superior to CTA in detecting a pedunculate thrombus. With the application of the ECG synchronization technique, cardiac CT successfully acquired accurate images of the highly mobile lesion, by reducing movement artifacts.

Cardiac CT has certain technical limitations. Thrombi smaller than 4 mm are very difficult to detect.<sup>14)</sup> Since it involves static imaging, thrombus mobility, which is an important risk factor for peripheral recurrent embolism,<sup>15)</sup> cannot be evaluated. Moreover, in clinical practice, patient cooperation with immobilization and a short breath hold is required. The most significant drawback is that it cannot evaluate ASD and PFO.

In conclusion, while cardiac CT is already a well-established and widely used examination in the field of cardiology, it is not yet accepted as a customary tool to detect the embolic source of stroke. Although there are some disadvantages, its less invasiveness may contribute to our clinical practice. To the best of our knowledge, this is the first case report of AMT of the ascending aorta to highlight the apparent difference between CTA and cardiac CT imaging. Although TEE, which is capable of detecting etiologies such as aortic disease and cardiac shunt disease, is still the standard examination for routine embolic exploration, cardiac CT may play a role as an alternative tool aimed to

detect small size AMT especially in patients who cannot bare the physical stress of TEE.

## Conflicts of Interest Disclosure

No disclosures to declare.

## References

- 1) Gaylis H: Primary aortic thrombosis. *Circulation* 17: 941–944, 1958
- 2) Aldaher MK, El-Fayed HM, Malouka SA, Gad FS: Large aortic arch mural thrombus in non-atherosclerotic thoracic aorta—a rare cause of stroke in the young. *BMJ Case Rep* 2015: bcr2015212887, 2015
- 3) Weiss S, Bühlmann R, von Allmen RS, et al.: Management of floating thrombus in the aortic arch. *J Thorac Cardiovasc Surg* 152: 810–817, 2016
- 4) Hart RG, Diener HC, Coutts SB, et al.: Cryptogenic stroke/ESUS International Working Group: embolic strokes of undetermined source: the case for a new clinical construct. *Lancet Neurol* 13: 429–438, 2014
- 5) Machleder HI, Takiff H, Lois JF, Holburt E: Aortic mural thrombus: an occult source of arterial thromboembolism. *J Vasc Surg* 4: 473–478, 1986
- 6) Laperche T, Laurian C, Roudaut R, Steg PG: Mobile thromboses of the aortic arch without aortic debris. A transesophageal echocardiographic finding associated with unexplained arterial embolism. The Filiale Echocardiographie de la Société Française de Cardiologie. *Circulation* 96: 288–294, 1997
- 7) Bok SK, Lee YJ, Ahn SY: Recurrent cerebral infarction caused by mobile aortic arch thrombus refractory to warfarin therapy. *Ann Rehabil Med* 37: 750–754, 2013
- 8) Pagán RJ, Parikh PP, Mergo PJ, et al.: Emerging role of cardiovascular CT and MRI in the evaluation of stroke. *AJR Am J Roentgenol* 204: 269–280, 2015
- 9) Popkirov S, Schlegel U, Weber W, Kleffner I, Altenbernd J: Cardiac imaging within emergency CT angiography for acute stroke can detect atrial clots. *Front Neurol* 10: 349, 2019
- 10) Yagyu T, Naito M, Kumada M, Nakagawa T: Aortic mural thrombus in the non-atherosclerotic aorta of patients with multiple hypercoagulable factors. *Intern Med* 58: 381–385, 2019
- 11) Barazangi N, Wintermark M, Lease K, Rao R, Smith W, Josephson SA: Comparison of computed tomography angiography and transesophageal echocardiography for evaluating aortic arch disease. *J Stroke Cerebrovasc Dis* 20: 436–442, 2011
- 12) Romero J, Husain SA, Kelesidis I, Sanz J, Medina HM, Garcia MJ: Detection of left atrial appendage thrombus by cardiac computed tomography in patients with atrial fibrillation: a meta-analysis. *Circ Cardiovasc Imaging* 6: 185–194, 2013
- 13) Pandya DJ, Gilkeson RC, Suarez JJ, et al.: Interobserver and intraobserver reliabilities of multislice electrocardiogram-gated spiral computerized tomography

- in evaluating aortic atheroma in patients with acute ischemic stroke. *Clin Imaging* 32: 109–113, 2008
- 14) Feuchtner GM, Stolzmann P, Dichtl W, et al.: Multislice computed tomography in infective endocarditis: comparison with transesophageal echocardiography and intraoperative findings. *J Am Coll Cardiol* 53: 436–444, 2009
- 15) Tenenbaum A, Motro M, Shapira I, et al.: Retrograde embolism and atherosclerosis development in the human thoracic aorta: are the fluid dynamics explanations valid? *Med Hypotheses* 57: 642–647, 2001

---

Corresponding author: Ryuichi Noda, MD  
Department of Neurosurgery, NTT Medical Center  
Tokyo, 5-9-22 Higashi-Gotanda, Shinagawa-ku, Tokyo  
141-8625, Japan.  
*e-mail*: rnrn46\_8447@yahoo.co.jp