

Letter



Treatment of Ischemic Stroke Following Intracranial Hemorrhage in a Patient with Continuous Flow Left Ventricular Assist Device: Between a Rock and a Hard Place

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CASE PRESENTATION

A 75-year-old male with a continuous-flow left ventricular assist device (LVAD) was brought to the emergency room (ER) after losing consciousness due to head trauma following orthostatic dizziness. At the ER, non-contrast brain computed tomography (CT) showed no evidence of intracranial hemorrhage (**Figure 1A and B**), and the patient exhibited no neurological deficits. He had an LVAD (Heartware Ventricular Assist Device System; Medtronic Inc., Minnesota, MN, USA), implanted 14 months prior to presentation, due to ischemic cardiomyopathy. After successful LVAD treatment for the destination therapy, he was treated with aspirin and warfarin with an international normalized ratio (INR) target of 2–3. His vital signs and basic laboratory test results were normal, but the INR was slightly elevated at 3.43. The LVAD setting was stable with a revolution of 2,500/min, flow of 3.5 L/min, and power of 3.2 watts. He was discharged with a decreased dose of warfarin from 4.5 mg to 4 mg. Five days later, the patient returned to the ER due to dysarthria. His INR was within the target range (2.86), and the LVAD function was stable (2,500/min, flow 3.3 L, power 3.2 watts). However, brain CT revealed multiple traumatic subarachnoid and intra-parenchymal hemorrhages (**Figure 1**). Vitamin K (10 mg) was immediately injected, and antithrombotic drugs (aspirin and warfarin) were discontinued. The target mean blood pressure was 65–80 mmHg. His symptoms improved, and a follow-up brain CT scan showed reduced hemorrhagic lesions. On the 16th post-admission day (PAD), he lost consciousness again. His vital signs and LVAD function (2,500/min, flow 3.1 L, power 3.1 watts) remained stable. Transthoracic echocardiography also showed no change in interval from the previous examination, and there was no evidence of intracardiac thrombosis. Brain CT angiography was performed instead of brain magnetic resonance imaging (MRI). It revealed total occlusion of the left middle cerebral artery (MCA) (**Figure 2**). During endovascular revascularization therapy, the total occlusion of the left MCA M2 segment was identified. The thrombectomy was successful, resulting in complete recanalization within 3

Ischemic Stroke with Hemorrhagic Stroke in LVAD

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Conflict of Interest

The authors have no financial conflicts of interest.

Author Contributions

Conceptualization: Lee HJ, Kim YS, Jang WS, Kim KT, Kim CH, Kim IC; Supervision: Kim KT, Kim CH, Kim IC; Visualization: Lee HJ, Kim YS, Kim IC; Writing - original draft: Lee HJ; Writing - review & editing: Kim YS, Jang WS, Kim IC.

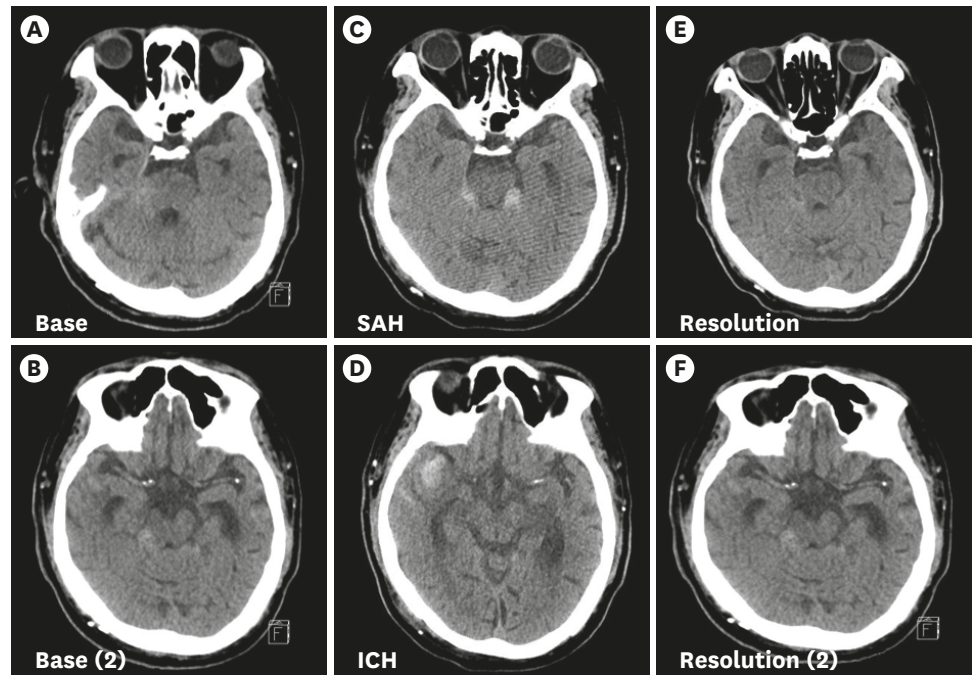


Figure 1. Brain CT images. (A, B) Initial brain CT imaging showed no evidence of brain hemorrhage. (C) Minimal SAH (white arrow) and (D) ICH (white arrowhead) 5 days after the initial event. (E, F) Follow-up brain CT on post-admission day 16 showed brain hemorrhage resolution. CT = computed tomography; SAH = subarachnoid hemorrhage; ICH = intracranial hemorrhage.

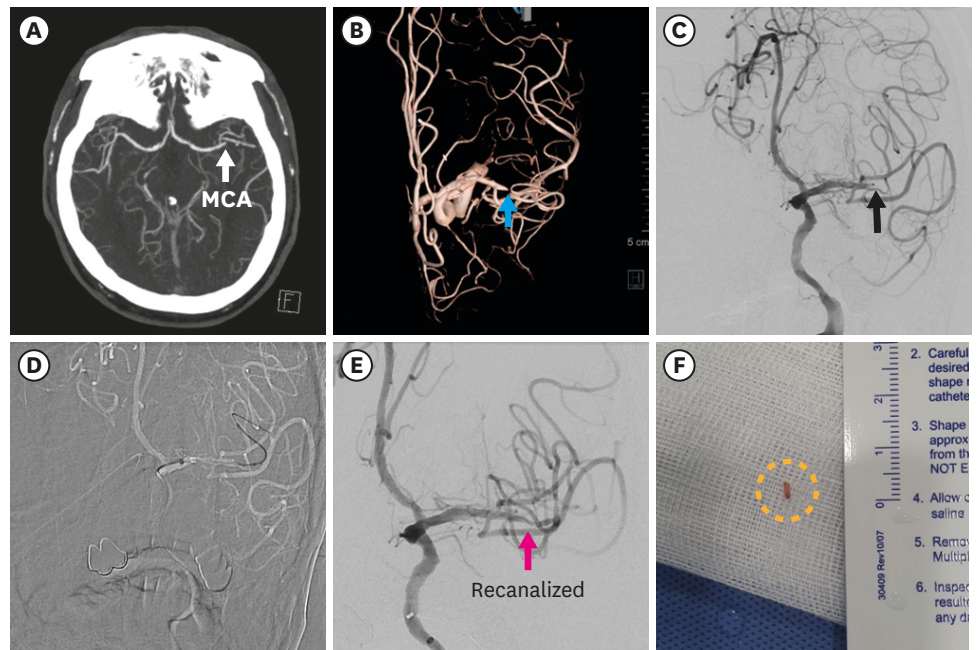


Figure 2. Brain CT and percutaneous vascular intervention imaging. (A) Brain CT imaging showed the occluded M2 portion of the MCA (white arrow). (B) Three-dimensional reconstruction CT imaging showed critical stenosis at the M2 portion of MCA (blue arrow). (C) Pre-thrombectomy angiography also showed critical stenosis of the MCA (black arrow). (D) Percutaneous intra-arterial thrombectomy was performed using an Embotrap device. (E) Post-thrombectomy angiography showed complete restoration of blood flow (red arrow). (F) Retrieved thrombotic plaque (dotted circle). CT = computed tomography; MCA = middle cerebral artery.

hours after the first symptom onset (**Figure 2**). The patient regained consciousness, and the follow-up CT scan showed cerebral hemorrhage resolution. Fortunately, the LVAD function remained stable despite total discontinuation of antithrombotic treatment (2,500/min, flow 3.5 L, power 3.3 watts). Warfarin was restarted at the 24th PAD after discussing with the neurosurgical department. The patient was discharged on the 30th PAD.

Ethical approval statement

The protocols and procedures adopted in this case complied with the Declaration of Ethics. However, this has not been approved by an ethical board.

DISCUSSION

In patients receiving continuous LVAD support, acute stroke has been associated with a high mortality rate and impaired quality of life. For patients with bridge-to-transplantation, the disability caused by acute stroke interferes with cardiac rehabilitation after heart transplantation.¹⁾ The incidences of ischemic cerebrovascular accidents (ICVA) and hemorrhagic cerebrovascular accidents (HCVA) in patients with LVAD were higher than those of healthy populations. The incidences of ICVA and HCVA (including hemorrhagic conversion of ICVA) among these patients were approximately 10.6% and 13.2%, respectively.²⁾³⁾ The mortality rate of HCVA was reportedly higher than that of ICVA (63–80.7% vs. 37–45.3%).¹⁾³⁾ Multiple mechanisms have been reported as causes of both HCVA and ICVA. These include anticoagulation, micro-thrombi caused by rotating metallic motor, and increased fluid shear stress.

We suggest a clinical algorithm for the ventricular assist device (VAD) patients with possible stroke based on the ‘Suspected Stroke Algorithm’ by the American Stroke Association (**Figure 3**). If a stroke is suspected in a VAD patient by the symptoms and signs, immediate general assessment and stabilization of vital sign should be achieved. Brain CT angiography need to be performed since brain MRI is not feasible for VAD patients. Decision should be made whether to use intravenous tissue plasminogen activator, perform mechanical thrombectomy or proceed conservative treatment when ICVA is diagnosed. On the contrary, physicians need to consider discontinuing antithrombotics with administration of vitamin K for the reversal of warfarin effect when HCVA is diagnosed. Thrombosis of VAD should be closely monitored during the discontinuation of antithrombotics. When there are no definitive findings of either infarction or hemorrhage, delayed and repeated imaging or electroencephalography (EEG) should be performed. If the neurologic finding of the patient changes, it is reasonable to consider repeat imaging or EEG as well. With the cooperation of the VAD team and the stroke team, the patient should be closely monitored in the intensive care unit (cardiac care unit or stroke care unit), and the status of VAD need to be carefully evaluated for the best outcome.

Patients with HeartMate 3 (HM3) reportedly had a reduced likelihood of stroke compared to those with HeartMate II.⁴⁾ There are no randomized trials comparing the stroke events between HVAD and HM3. However, fully magnetically-levitated LVAD was beneficial in terms of stroke events, according to a single-center retrospective study.⁴⁾

The Heartware Ventricular Assist Device has been withdrawn from the market since June 2021 due to safety issues. However, a similar approach is helpful for the fully magnetically-levitated device, HM3.

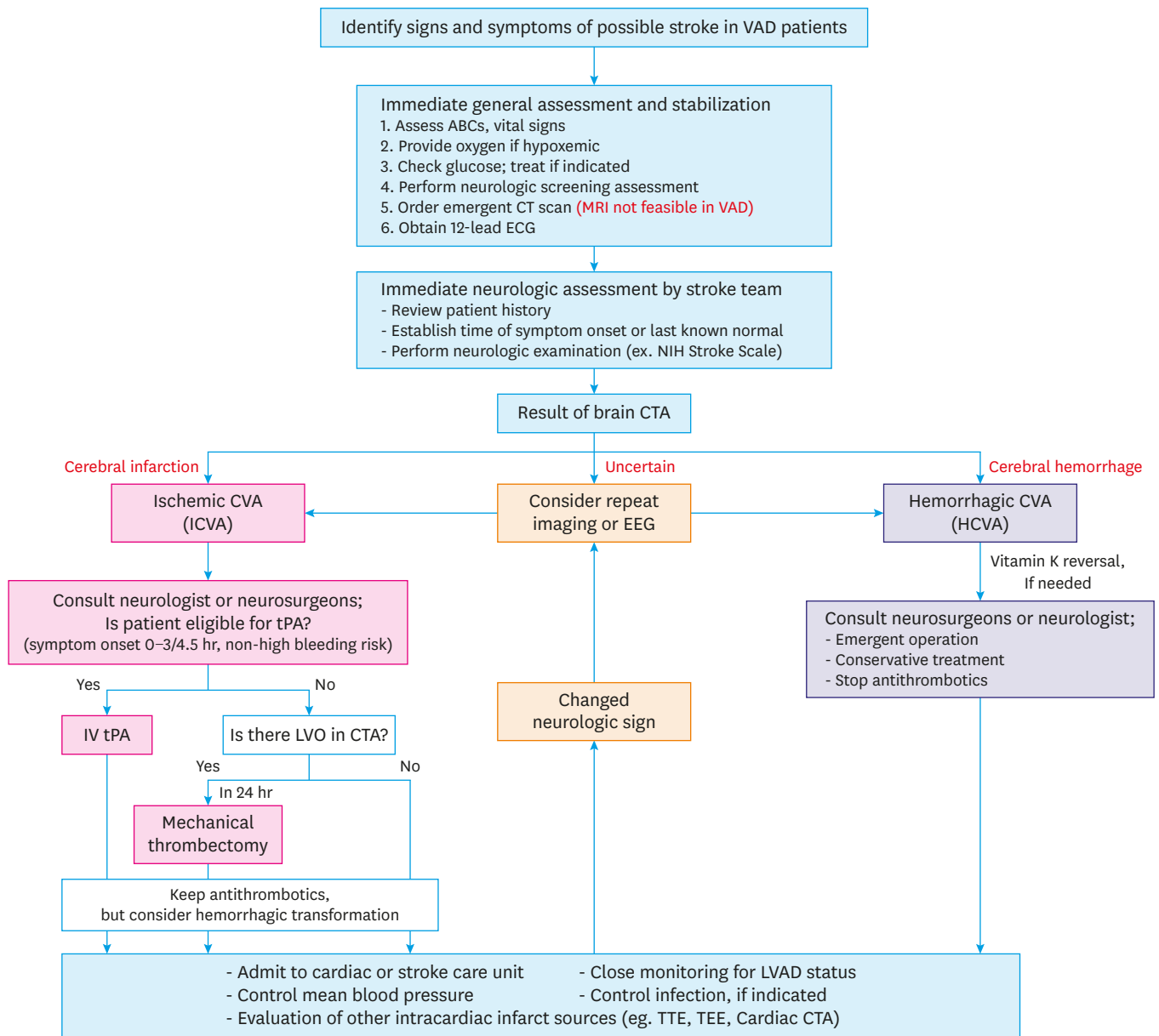


Figure 3. Schematic figure showing management pathway of ICVA or HCVA during VAD based on ‘Modified Suspected Stroke Algorithm Goals by American Stroke Association’.

ICVA = ischemic cerebrovascular accidents; HCVA = hemorrhagic cerebrovascular accidents; LVAD = left ventricular assist device; ECG = electrocardiography; CT = computed tomography; CTA = computed tomography angiography; tPA = tissue plasminogen activator; LVO = large vessel occlusion; TTE = transthoracic echocardiography; TEE = transesophageal echocardiography; EEG = electroencephalography; VAD = ventricular assist device; MRI = magnetic resonance imaging; NIH = National Institutes of Health.

Superimposed ICVA on HCVA is difficult to manage, especially in patients with LVAD. Timely management using a brain CT and cerebrovascular interventions is key to successfully treat these patients because an MRI is not feasible. A multidisciplinary team approach is also important to overcome high-risk situations.

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