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Case report

Postoperative cerebral air embolism with delayed abnormal brain MRI findings

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ABSTRACT

Cerebral air embolism (CAE) is a rare but well-known complication resulting from invasive medical procedures; however, previous studies have not examined the postoperative longitudinal MRI changes in CAE. In particular, the likelihood that such changes may be observed after an initial delay when using magnetic resonance imaging (MRI) has not been explored. We herein report a case of CAE with no MRI abnormalities 4 h after a pulmonary vein isolation (PVI) procedure and where the first abnormality was found 22 h after the procedure.

A 65-year-old man underwent PVI for paroxysmal atrial fibrillation and showed no signs of recovery from anesthesia after the procedure; thus, he was transferred to our emergency department for further examination. Neurological examination revealed conjugate eye deviation to the right and quadriplegia. Although initial computed tomography (CT) and MRI revealed no abnormalities, CAE was suspected, and a high-concentration oxygen treatment was administered. MRI performed 22 h after the procedure revealed restricted diffusion affecting the cortical areas. At the same day, he was transferred for hyperbaric-oxygen chamber treatment. After 7 days of treatment, the patient recovered clinically and neurologically. He regained consciousness and was able to communicate.

As suggested by this case, CT and MRI findings may fail to reveal CAE abnormalities initially. In such cases, as urgent treatment is necessary, it is important to consider diagnosing CAE based on the patient's history and administering a high concentration of oxygen. Finally, to reach a correct diagnosis, repeated brain MRI should be considered for patients with suspected CAE.

1. Introduction

Cerebral air embolism (CAE) is a rare but well-known complication that may result from invasive medical procedures. Furthermore, air embolism related to pulmonary vein isolation (PVI) is a very rare complication, with only 0.2% of patients experiencing this adverse event [1]. In a systematic review of cerebral gas embolisms associated with central venous catheters, normal brain MRI findings were reported in only 13% of the patients [2]. Nevertheless, reports on CAE have not elaborated on the longitudinal changes in MRI imaging; in particular, the detection of such changes using MRI may be delayed. Herein, we report a case of CAE with no MRI abnormalities found 4 h following a PVI procedure and abnormalities found 22 h after the procedure.

2. Case report

A 65-year-old man with a past medical history of stroke was taking dabigatran etexilate and underwent PVI for paroxysmal atrial fibrillation. During the procedure, the patient experienced a transient drop in blood pressure; Electrocardiogram showed a depressed ST segment, and ischemic heart disease was suspected. As initial coronary angiography revealed the presence of gas in the right coronal artery, intravenous nicorandil was administered, and coronary angiography was repeated 20 min later, showing no signs of gas. Following the procedure, the patient showed no signs of recovery from anesthesia and experienced impaired consciousness. Thus, he was transferred to our emergency department for further examination and treatment.

On arrival to our emergency department, the patient experienced an altered mental state that manifested as impaired awareness. A neurological examination revealed conjugate deviation of the eyes to the right

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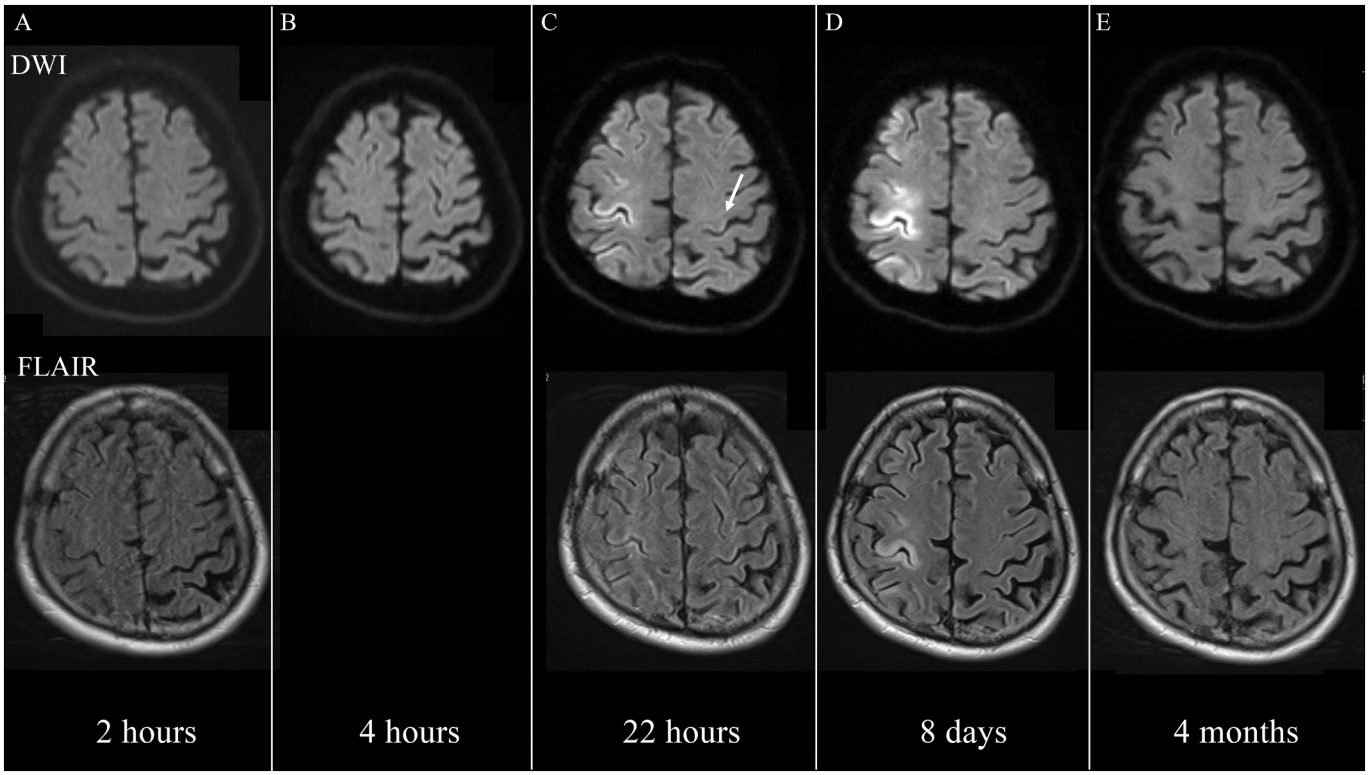

Fig. 1. Longitudinal MRI changes (A) DWI and FLAIR 2 h after the procedure. (B) DWI 4 h after the procedure. (C) DWI and FLAIR 22 h after the procedure, showing restricted diffusion affecting cortical areas in bilateral hemispheres. Arrow shows restriction at the precentral gyrus. (D) DWI and FLAIR 8 days after and (E) DWI and FLAIR 4 months after the procedure.
DWI, diffusion-weighted images; FLAIR, fluid-attenuated inversion recovery.

Table 1
Reports of diffusion restriction initially found after onset.

	No diffusion restriction	Diffusion restriction initially found
Suzuki et al. [3]	1 h after onset	12 h after onset
Kang et al. [4]	2 h after onset	18 h after onset
Hirasawa et al. [5]	3 and 6 h after onset	1 week after onset
Our case	2 and 4 h after onset	22 h after onset

and quadriplegia, whereas the Babinski reflex was bilaterally positive. Computed tomography (CT) scan performed within 2 h of PVI showed no abnormal density areas. Initial magnetic resonance images (MRIs) were obtained 2 h following the procedure. Diffusion-weighted images (DWI) demonstrated no acute ischemic changes (Fig. 1A). Although MRIs showed no abnormalities, CAE was suspected based on the patient's medical history. Hence, high-concentration oxygen treatment was administered at the emergency department. Four hours after the procedure, DWI still did not show any acute ischemic changes (Fig. 1B). Repeated diffusion-weighted and apparent diffusion coefficient (ADC) images obtained 22 h following the procedure showed restricted diffusion affecting the cortical areas of the right hemisphere, including the precentral gyrus. Restriction of the left precentral gyrus was also suspected, which explained his quadriplegia (Fig. 1C, arrow). This time, his quadriplegia consciousness showed slight recovery. Since high-concentration oxygen treatment is only a supportive maneuver, the patient was transferred for hyperbaric-oxygen chamber for further treatment, 28 h after onset. He was treated for 7 days retransferred to our hospital. On day 8, both DWI and fluid-attenuated inversion recovery (FLAIR) indicated hyperintensity (Fig. 1D). Eventually, the patient recovered clinically and neurologically. He regained consciousness and was able to communicate. Four months after the procedure, restricted diffusion had improved (Fig. 1E). At this point he was alert, but weakness of the left upper extremity remained.

3. Discussion

In this case, MRI did not reveal any abnormalities within the first 4 h of the procedure, and DWI hyperintensity and low ADC were first observed using MRI 22 h after the procedure. Few CAE cases in which initial MRI failed to detect any abnormalities but later revealed diffusion restriction have been mentioned in previous literature (Table 1) [3–5]. CAE results from gas being transferred to small arteries (average diameter, 30–60 μm) [6].

Two possible mechanisms explain the pathological changes resulting from CAE. First, obstruction of arterial blood flow disrupts the metabolic processes of neurons, resulting in cytotoxic edema. Second, the surface of the gas bubble generates leucocyte activation through endothelium interface. The gas bubble also mechanically irritates the arterial endothelium, resulting in vasogenic edema and greater impairment of perfusion [6,7]. The difference in this mechanism from the mechanism that occurs in typical arterial infarction cases may explain why diffusion restriction occurs with a delay in CAE cases.

Although CAE is a rare complication of PVI, a delayed recovery from anesthesia may suggest CAE in patients who have undergone surgical procedures that carry a risk of CAE. As in the present case, the CT and MRI may fail to reveal any abnormalities initially. However, as urgent treatment for CAE is crucial, it is important to consider diagnosing CAE based on the patient's history and administering a high concentration of oxygen as a supportive maneuver. In case that CT and MRI findings reveal no abnormalities initially, brain MRI should be repeated for patients with suspected CAE to reach a correct diagnosis. Additionally, possibility of cerebral venous air embolism may also have played a role, and caused the delayed imaging changes [8].

Nonetheless, as only a few studies have previously reported on the

longitudinal changes in the brain MRI that occur during CAE, accumulation of further cases is necessary to support the results of this study.

Author contributions

Study concept and design: YO and KT; Acquisition and analysis of data: YO, KT, AK, and MK; Writing the first draft: YO and KT; Revising the manuscript for important intellectual content: AK, MK and TH. All authors read and approved the final manuscript.

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Declaration of Competing Interest

All authors report no conflicts of interest.

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