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Case Report

Symptomatic Cerebral Air Embolism During Stent-assisted Coiling of an Unruptured Middle Cerebral Artery Aneurysm: Intraoperative Diagnosis and Management of a Rare Complication

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Symptomatic cerebral air embolism during cerebral angiography is extremely rare. We report on the case of a 69-year-old woman undergoing elective stent-assisted coiling of an unruptured right middle cerebral artery (MCA) bifurcation aneurysm, who was found to have severe attenuation of somatosensory evoked potential (SSEP) and electroencephalography (EEG) during the procedure. Intra-operative DynaCT showed hypodense cortical vessels consistent with cerebral air embolism. Diagnostic and management strategies for this rare complication are reviewed.

Keywords Cerebral air embolism, Cerebral angiography

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INTRODUCTION

Symptomatic cerebral air embolism (CAE) is a rare complication associated with cerebral angiography with a reported incidence of 0.08%.[2] Clinical manifestations of symptomatic CAE may include decreased level of consciousness, hemiparesis, seizures, and neuromonitoring changes while under anesthesia.[6] Early recognition, diagnosis, and treatment of CAE can minimize irreversible neurological deficits and avoid potential mortality. We report on a rare case of CAE, which highlights that symptomatic CAE should be considered in differential diagnoses when abnormal neuromonitoring signals are observed during cerebral angiography and prompt treatment can minimize neurological deficits. Strategies for diagnosis and management of this rare complication are reviewed.

CASE REPORT

A 69-year-old female presented for elective stent-assisted coiling of a 7 mm, unruptured right middle cerebral artery (MCA) bifurcation aneurysm. She was started on aspirin 325 mg and clopidogrel 75 mg daily seven days prior to undergoing the elective procedure. She was taken to the endovascular suite and underwent general endotracheal anesthesia without complication. Neuromonitoring with electroencephalography (EEG) and somatosensory evoked potential (SSEP) were set up with good quality baseline signals prior to starting the procedure.

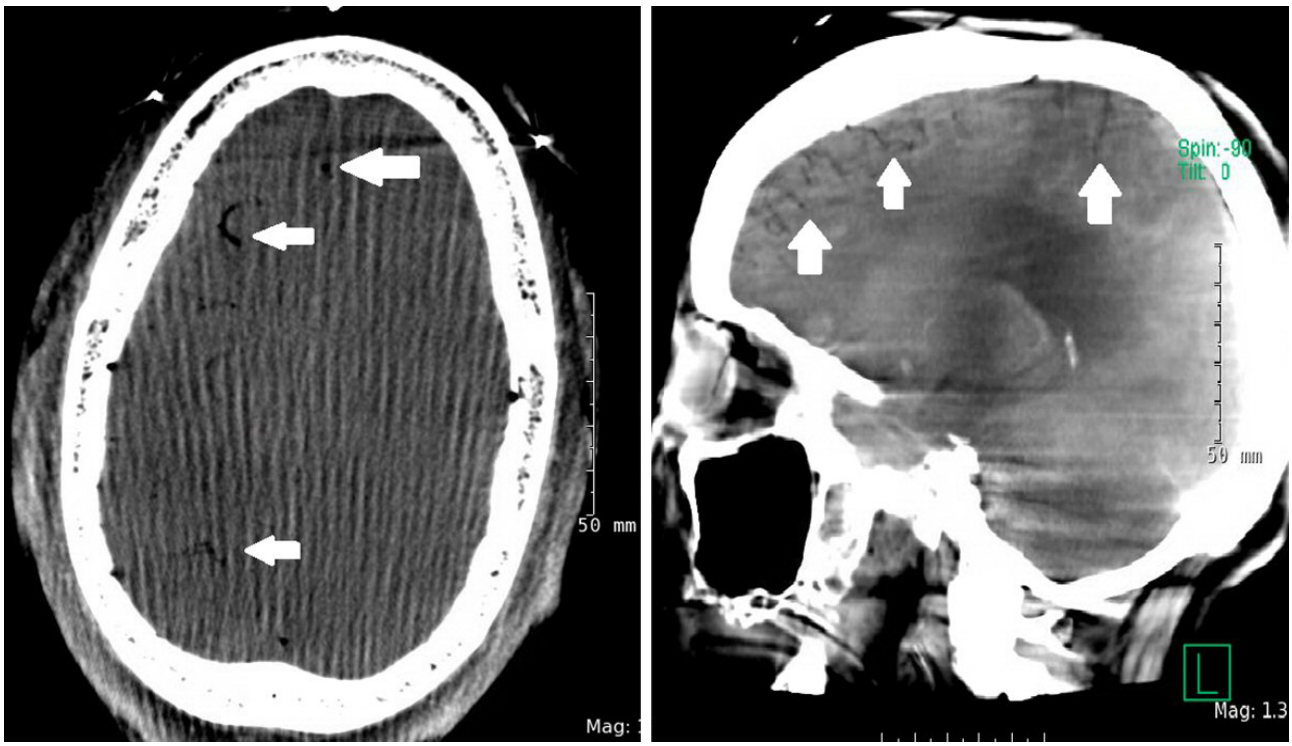

Fig. 1. Intraoperative DynaCT showing air emboli outlining cortical vessels with air serving as a negative contrast medium.

A 6-French Neuron guide catheter (Penumbra Inc., Alameda, CA, USA) was advanced over a 5-French Berenstein catheter for selection of the patient's right common carotid artery. Using a roadmap technique and over-the-wire technique, the diagnostic catheter was used for selection of the patient's right internal carotid artery. A microcatheter (Excelsior SL-10, Stryker Neurovascular, Fremont, CA, USA) and a wire (Synchro-14, Stryker Neurovascular) were then used for selective catheterization of the MCA and coiling of the MCA aneurysm was started.

During coiling of the aneurysm however, the neurophysiologist reported severe attenuation of SSEPs in the bilateral upper and lower extremities along with near flatlining of the EEG. The EEG and SSEP electrodes were verified to have good contact with the patient. There was no change in anesthetics, blood pressure, or body temperature prior to the SSEP and EEG change. A cerebral angiogram was performed and showed patent large cerebral vessels. An intraoperative DynaCT was then obtained and showed multiple, hypodense cortical vessels consistent with cerebral air embolism (Fig. 1). At this time, it was noted that the pressure bag was depleted and a small amount of air was present in the drip line tubing. The drip line and catheter were flushed immediately and cleared of air. The FiO2 was increased to 100% on the ventilator, intravenous levetiracetam was administered, mean arterial blood pressure was increased, and intra-arterial verapamil infusion was administered in order to facilitate vasodilatation and to maximize cerebral perfusion. The SSEP and EEG signals showed gradual improvement approximately 30 minutes after the initial change.

Given the patient's improvement on neuromonitoring and risk of coil migration, an Enterprise stent (4.5 × 22 mm; Cordis, Bridgewater, NJ, USA) was deployed successfully across the aneurysm for completion of the procedure. The patient was heparinized with adequate activated clotting time prior to stent placement. The catheter was retracted out of the body. A 6-French Angio-Seal closure device (St. Jude Medical,

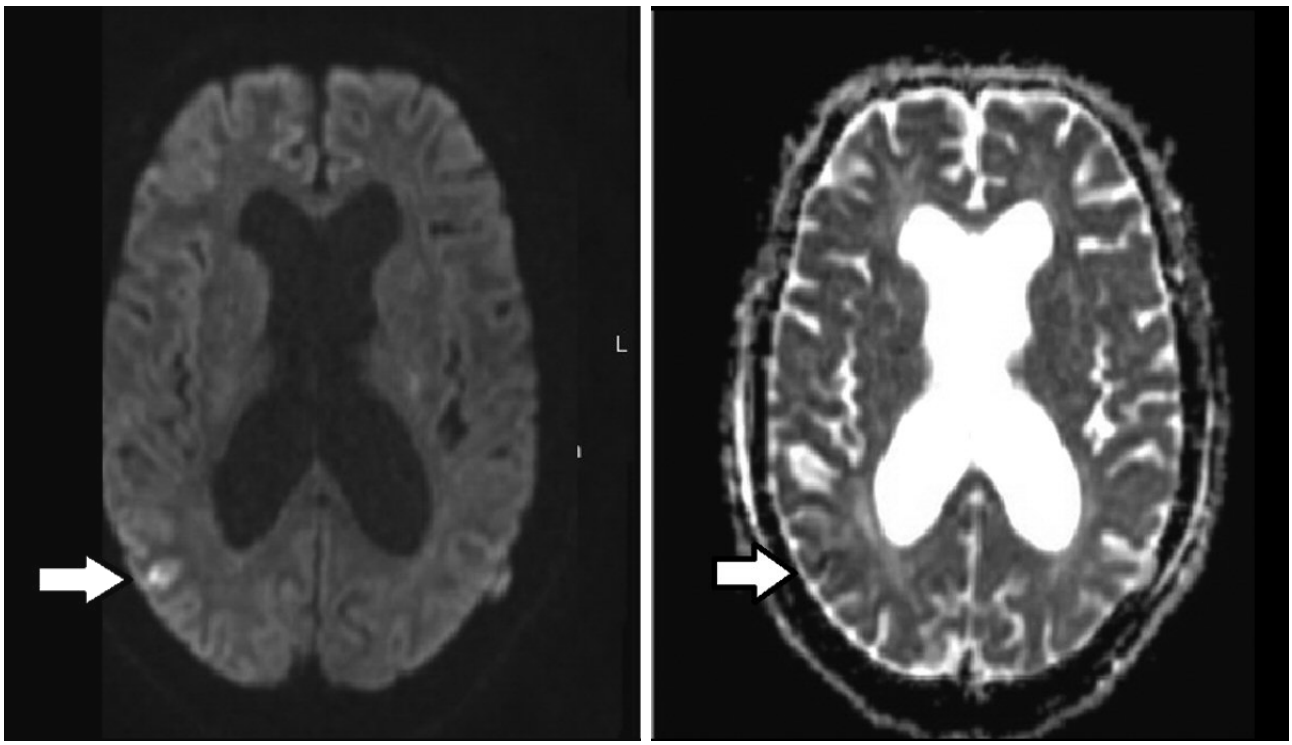

Fig. 2. Post-procedural magnetic resonance imaging showing only a small focal area with restricted diffusion in the right parietal region.

St. Paul, MN, USA) was deployed successfully.

The patient was taken to the intensive care unit postoperatively and remained intubated. Neurological examination revealed hemiparesis on the left. Magnetic resonance imaging (MRI) of the brain showed only a small focal area with restricted diffusion in the right parietal region (Fig. 2). The patient's left hemiparesis showed gradual improvement over the next few days and she was eventually discharged with near baseline strength. Follow-up angiogram at four weeks showed Raymond grade 1 occlusion of the right MCA aneurysm (Fig. 3) and she was doing well without any clinically significant deficit.

DISCUSSION

Cerebral air embolism is known to occur in a number of clinical settings, including cranial surgeries in the sitting position, trauma, decompression sickness, and cardiopulmonary bypass procedures.[6] In many of these situations, air first enters into the venous circulation and subsequently migrates to the arterial side from either a patent foramen ovale or other cardiopulmonary shunts (paradoxical embolism). During cerebral angiography, however, air can be introduced directly into the arterial circulation and therefore is more likely to cause neurological symptoms. Fortunately, the overall incidence of symptomatic CAE associated with cerebral angiography is extremely low. In a study examining more than 4,500 cerebral angiographies, only four cases of symptomatic CAE were observed, representing only 0.08% of all cases. Of particular interest, all four cases of CAE occurred during interventional cases and conferred a risk of 0.2%.[2]

Several sources for air emboli in the setting of cerebral angiography have been reported in the literature, including air bubbles in the flush syringe, air bubbles in improperly primed flush tubing, non-degassed pressure bag, accidentally opened 3-way stopcock during an episode of hypotension, and rupture of an

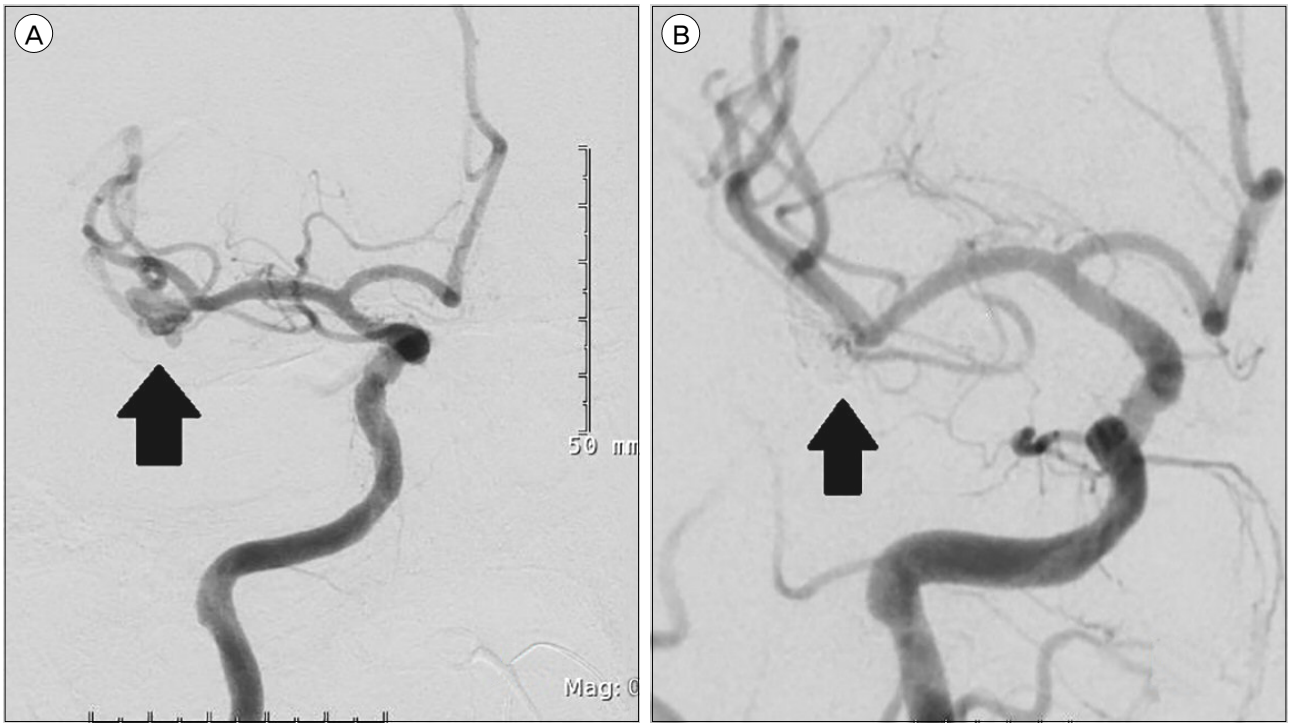

Fig. 3. (A) Pre-procedural cerebral angiogram showing the 7 mm right middle cerebral artery bifurcation aneurysm with complex morphology. (B) Follow-up cerebral angiogram showing a Raymond grade 1 occlusion of the aneurysm.

inadequately degassed angioplasty balloon.[2)4)] In our case, air was introduced from the pressure bag, which had been inadequately degassed prior to the procedure; when the pressure bag was depleted, the small amount of residual air in the bag subsequently moved into the drip line, the guide wire, and eventually into the cerebral vasculatures.

When CAE is suspected during cerebral angiography, a quick angiogram can be helpful in assessment for any large vessel occlusion. Computed tomography (CT) or DynaCT, if available, is a quick way to look for intracranial air, which can often demonstrate the outline of affected cerebral vasculature as the air emboli serve as a negative contrast medium. MRI can also demonstrate intracranial air as hypointensity on T1-weighted sequence, however, the time requirement and patient transport often limit its role in acute diagnosis of CAE; however, MRI is valuable in assessing the extent of ischemic changes due to CAE.

Once the diagnosis of CAE has been established, several measures can be taken to minimize potential neurological deficits. First, 100% O_2 can be used to dilute nitrogen in the air emboli (same composition as the earth's atmosphere, ~ 78% N_2 and 21% O_2) and facilitate absorption of air. Second, mean arterial pressure can be raised to increase cerebral blood flow, which helps to increase perfusion of the affected area from collateral vessels and to increase the rate of air absorption. Third, as in our case, intra-arterial verapamil infusion can potentially increase cerebral vessel dilation to maximize cerebral perfusion and to facilitate more distal migration of air emboli. Another important treatment option for CAE is placing the patient in a hyperbaric chamber, where increased pressure can decrease air emboli size and increase the amount of gas molecules dissolved in the blood stream. However, the utilization of hyperbaric chambers is limited by availability. Finally, early prophylactic anticonvulsants should also be considered, given that many patients with CAE are prone to having seizures.

Prevention of CAE is paramount in every neurointerventional case and all potential sources for introduction of air into the drip line should be checked carefully prior to starting any procedure. The prognosis of CAE depends on a combination of several factors, including the amount of air present, collateral circulation, time of diagnosis, time of intervention, and treatment strategies utilized. Many patients with CAE can have complete recovery; however, permanent neurological injuries and mortality can also occur if diagnosis and proper intervention is delayed.[1-6)]

CONCLUSION

Symptomatic cerebral air embolism is a rare but important complication associated with cerebral angiography which all neurointerventional surgeons should bear in mind. With prompt diagnosis and appropriate management, major permanent neurological deficits and mortality can often be avoided.

Disclosure

This authors have no personal financial or institutional interest in any of the materials or devices described in this article.

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