Pearls & Oy-sters: Enhancing vigilance for detection of cerebral air embolism

From syncope to death

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Pearls

- Cerebral air emboli (CAE) are scattered, small, distally located, and characteristically of low density on CT scan.
- CAE should be considered as a stroke etiology in appropriate cases.
- Prevention is a key treatment strategy.

Oy-sters

- All techniques that involve positive pressure instrumentation or involve exposure of major blood vessels, especially in patients with suspected cancer or tissue disruption, should be performed with additional caution.
- Patient positioning during and after procedures, type of gas used for positive pressure generation, effectiveness of hyperbaric chambers, and identifying anatomical predictors that increase the risk of systemic air embolism are factors that need to be further investigated to minimize morbidity and mortality associated with CAE.

A 66-year-old man presented to the emergency department after an unwitnessed fall presumed to be caused by syncope. The patient had a medical history of hypertension, hyperlipidemia, diabetes mellitus type II, and paroxysmal atrial fibrillation on Eliquis.

Upon further evaluation, the patient reported daily postprandial, epigastric pain radiating to the back associated with dysphagia and weight loss over the last 3 months. An esophagogastroduodenoscopy (EGD) was performed and an ulcer was discovered in the midesophagus alongside a subepithelial mass partially obstructing the lumen. Initial pathologic examination of the biopsies obtained was suggestive of a gastrointestinal stromal tumor, leiomyoma, vs a primary esophageal cancer with subepithelial extension.

CT of the chest confirmed an esophageal mass with extension into the right mediastinum with scattered foci of intravascular air. Subsequent EGD was performed on day 4 for percutaneous endoscopic gastrostomy (PEG) with tube placement.

Final pathology results revealed an aggressive B-cell lymphoma. Prior to initiation of treatment, neurology was consulted for an acute post-tussive syncope followed by left arm and leg weakness with NIH Stroke Scale (NIHSS) score of 2. Blood pressure, finger stick, and ECG were normal at that time. An acute infarct was suspected because the patient was taken off anticoagulation for the recent PEG placement. CT head did not show any ischemia. Shortly after the CT scan, the patient developed right gaze along with global aphasia and left hemiplegia resulting in NIHSS of 16. CT angiography (figure) did not show any arterial abnormalities; however, a number of scattered, 1 mm, hypodense foci were seen in the right middle cerebral artery territory, presumed

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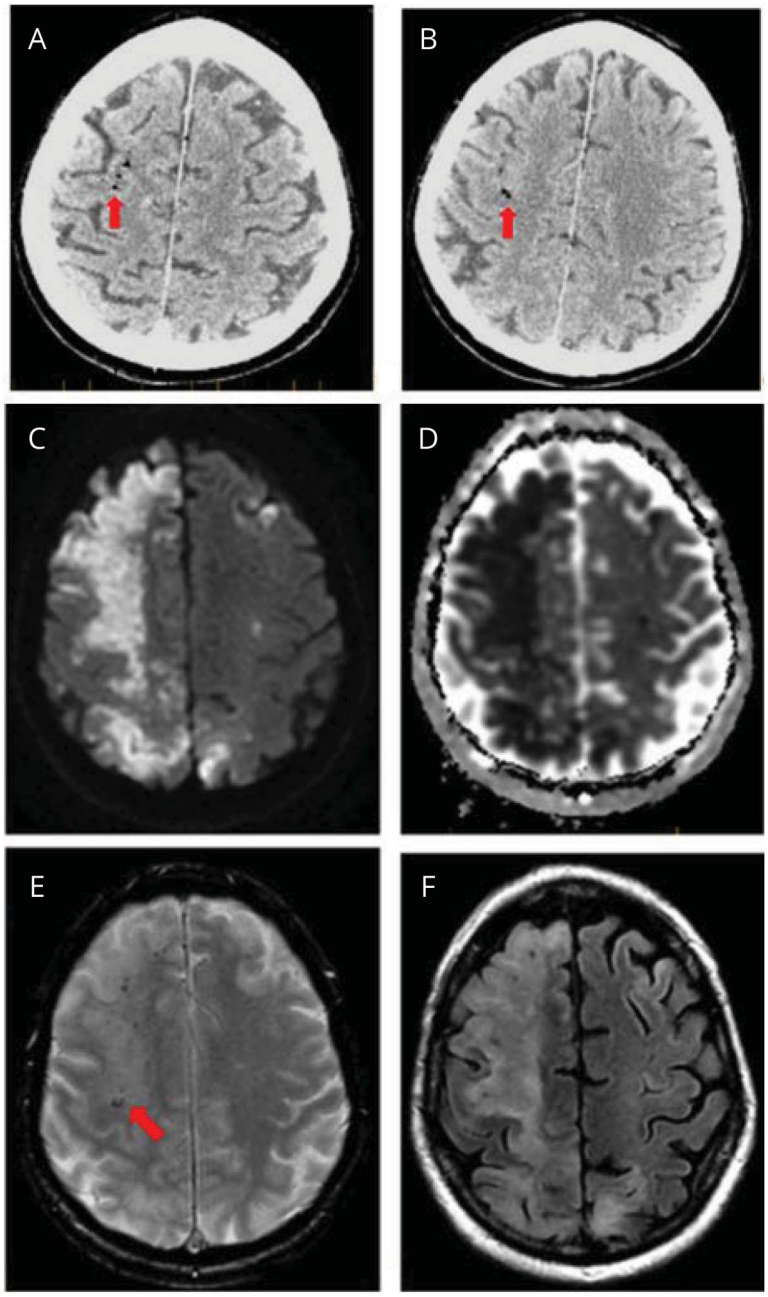

(A, B) Initial dry CT head shows air emboli (red arrows). (C, D) MRI brain with and without contrast. Diffusion and apparent diffusion coefficient demonstrate restriction indicating infarcted tissue in right middle cerebral artery (MCA) territory as well as some small left frontal and posterior parietal infarcts. The gradient recalled echo sequence (E) demonstrates microhypointensities (red arrow) along the right MCA territory, likely demonstrating the air emboli seen on CT. Fluid-attenuated inversion recovery (F) demonstrates the cytotoxic edema.

to represent air emboli. MRI (figure) confirmed a massive right-sided acute infarct without hemorrhagic transformation. Transthoracic echocardiogram showed normal ejection fraction without evidence of right to left shunting. EEG demonstrated moderate encephalopathy without epileptiform changes.

The patient's mental status continued to decline and he was subsequently intubated. Empiric antibiotics were initiated after development of 104°F fever. The patient deteriorated further with increasing cerebral edema and superimposed sepsis. Given the extent of brain injury, the family decided to withdraw care.

Discussion

We discuss a case of massive air embolism resulting in morbidity and subsequent mortality, a prognosis reviewed previously.[1] Since treatments are limited, prevention and early recognition of the at-risk population are paramount, yet pose a challenge given the uncommon and insidious nature of this condition. Hyperbaric oxygenation therapy (HBOT) has shown promise in reducing the air burden; however, it has not been fully defined and is not readily available.[2]

Arterial air embolism was first described in 1769.[2] There are about 20,000 reported CAE cases in the United States per year.[2]

The majority of air embolisms reported in the literature are iatrogenic and associated with IV or arterial lines, mechanical positive pressure ventilation, carotid endarterectomy, open heart surgery, endoscopic procedures, and hemodialysis.[1,2]

Air can enter the venous system if the atmospheric pressure is greater than the venous pressure. This can occur when central venous catheter insertion is performed in a supine position.[3] Similarly, air can be forced into the venous system when applying positive pressure during endoscopy in the setting of a venous tear or open ulcer.[4] From there, air can travel through a pulmonary arteriovenous malformation or cardiac shunt into the arterial system.[2] If enough air enters and overwhelms the lung's filtration system, it can diffuse into the arterial side.[3,5] Some authors have also proposed that venous cerebral air emboli can migrate to the brain parenchyma in a retrograde pattern.[6] When air bubbles reach the brain parenchyma, they induce activation of neutrophils and promote stasis, which leads to an infarct.[1] The precise pathophysiology has not been delineated. We postulate that due to the low pressure of the venous system, venous air emboli may not be as deleterious on the cerebral tissue as compared to arterial air emboli.

Symptoms of CAE can range from mild confusion to more severe symptoms including seizures or massive cerebral infarcts. Our patient had metastatic esophageal malignancy and 2 EGD procedures prior to his event. Both the malignancy and the EGD procedures are independent risk factors for the development of CAE. A mechanism of air entry previously proposed by Brennan et al.[7] argues that during swallowing the positive pressure produced in the esophagus forces air through a fistula into the left atrium. We could not visualize a fistula during our workup and autopsy was not performed. Past cases report strokes occurring during or after cancer treatment, but our patient had not begun any therapy. Therefore it is possible that our patient's cancer was discovered late in its course.

Gastrointestinal endoscopic procedures have been reported to have a 5%–25% relative risk of resulting in CAE when compared to other iatrogenic causes.[5] Intuitively, in arterial air emboli, the common areas of ischemia would be in the right hemisphere given that the right common carotid is usually the first direct branch off the aortic arch, as was the case in our patient. A 26-patient case series[8] and an 18-patient case series[4] had diagnosis of right hemispheric infarcts from CAE associated with endoscopic procedures. The air emboli in these case series were thought to occur in association with an interruption in the mucosal barrier. Our patient had an esophageal ulcer and a biopsy done in the setting of 2 EGD procedures.

The initial head CT and CT angiography scans both showed linearly scattered hypodensities along the internal carotid arterywatershed distribution mostly in the right hemisphere. The density of these lesions was consistent with air or fat. Knowing that the patient did not have any trauma or fractures, fat emboli were unlikely. Given the malignancy, we considered the possibility of Trousseau syndrome, but believed this was unlikely as it tends to occur with mucinous type tumors as opposed to lymphomas.[9] The hypodensities on the imaging were not consistent with fibrin or platelet-rich clots, which can result from Trousseau and other hypercoagulable syndromes. A brain MRI demonstrated a large right hemispheric acute infarction as well as smaller left hemispheric infarctions. The gradient echo sequence demonstrates linear hypointensities that correlate with the air emboli seen on the CT scan, as seen in prior studies.[10] Furthermore, in our patient, there was visible T1 postcontrast focal gyral (leptomeningeal) enhancement. This may have been due to contrast leakage into the CSF from damaged vessels. The cortex was involved as well as the surrounding subcortical areas as seen on T1, T2, and fluid-attenuated inversion recovery sequences, which further supports the arterial etiology of the infarcts. Conversely, if the etiology was venous, we suspect the affected regions would be superficial and cortical with a different pattern altogether.

The best treatments are recognition and prevention. One recommendation is to use CO_2 for endoscopic studies given the better absorption of this gas.[4] Hyperbaric oxygenation has also been used, which involves exposure to pure oxygen in a pressurized chamber to treat hypoxia and reduce air bubble size. Its efficacy is only validated through case reports, but a 78% success rate has been reported.[5] The Durant maneuver places the patient in the left lateral decubitus position in Trendelenburg to help remove the air bubbles from the cerebral vasculature.[2] Our patient's clinical deterioration and hemodynamic instability prohibited transfer to a HBOT facility.

The etiology of our patient's emboli was likely a result of the combination of esophageal cancer with a luminal tear in addition to positive pressure air induction from the EGD into the venous system. The patient likely had an esophageal–atrial fistula or overwhelmed the pulmonary filtration capacity allowing for venous air to travel into the arterial system.

The prognosis of CAE is variable and follows a spectrum of outcomes based on the amount of embolic burden present and rate at which air accumulates.[5] Neurologic deficits can be transient and resolve spontaneously or can result in devastating morbidity and subsequent mortality.

Author contributions

Dr. Mirtchev: treating physician, manuscript revision, main author. Dr. Mehta: background research, discussion author. Dr. Daniel: background research, discussion author. T. Finstein: background research, manuscript revision, editing, and formatting. Dr. McCullough: treating physician, main author.

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Disclosure

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