Iatrogenic Cerebral Air Embolism During Esophago-Gastroduodenoscopy

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Patient: Male, 72-year-old
Final Diagnosis: Air embolism • stroke
Symptoms: Altered mental status
Medication: —
Clinical Procedure: Endoscopy • esophagogastrroduodenoscopy • hyperbaric oxygen treatment • variceal banding
Specialty: Neurology • Radiology

Objective: Rare disease
Background: Cerebral air embolism is a rare iatrogenic complication of endoscopic procedures that can result in irreversible neurological damage. The symptoms of cerebral air embolism are nonspecific and may be attributed to sedation-related complications and central nervous system insults. Having awareness of this rare iatrogenic event and deciding on immediate imaging when it is suspected are essential for prompt diagnosis and treatment.

Case Report: A 72-year-old man with a past medical history of alcoholic liver cirrhosis with associated portal hypertension underwent an outpatient esophagogastrroduodenoscopy for surveillance of esophageal varices. During the procedure, the patient retched several times and developed a mucosal tear, which was repaired using endoscopic clips. After the procedure, the patient remained sedated for a prolonged time and was subsequently unresponsive. Nonenhanced CT of the head showed several foci of gas throughout the subarachnoid spaces. Follow-up nonenhanced brain magnetic resonance imaging demonstrated ischemic changes, which were more prominent along the right cerebral hemisphere.

Conclusions: Cerebral air embolism is an iatrogenic complication of endoscopic procedures that can result in irreversible neurological damage. It must be included in the differential diagnosis of a patient presenting with altered mental status and neurological deficits after an endoscopic procedure. Diagnostic imaging can be useful in identifying key features of this iatrogenic event. Timely diagnosis and treatment can improve patient outcomes.

MeSH Keywords: Embolism, Air • Endoscopy, Gastrointestinal • Iatrogenic Disease • Stroke

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Background

Cerebral air embolism is a rare iatrogenic complication of endoscopic procedures that can result in irreversible neurological damage. Endoscopic procedures require pressurized air insufflation, which can facilitate the introduction of air into the vascular system [1–4]. Most cases of cerebral air embolism are associated with disruption in the mucosa, which consequently exposes the vasculature to pressurized air, and in severe cases it may lead to hemodynamic instability or ischemia of end organs, such as the central nervous system. The symptoms of cerebral air embolism are nonspecific and may be attributed to sedation-related complications and central nervous system insults, such as ischemic or hemorrhagic stroke [2–4]. Therefore, cerebral air embolism must be suspected in patients presenting with neurologic symptoms after an endoscopic procedure to conduct prompt diagnosis and treatment. We present a case of an esophago-gastroduodenoscopy procedure complicated by a Mallory-Weiss tear that resulted in cerebral air embolism.

Case Report

A 72-year-old man with a past medical history of alcoholic liver cirrhosis and portal hypertension underwent esophago-gastroduodenoscopy for surveillance of esophageal varices. Midazolam was administered for conscious sedation. He retched several times during the procedure and bleeding was noted at the esophagogastric junction, which was associated with a small mucosal tear. The patient was subsequently treated using endoscopic clips and epinephrine injection. Air insufflation of the lumen was needed to allow adequate visualization for repair. After the procedure, the patient remained somnolent and unresponsive for a prolonged period. He was endotracheally intubated and transferred to our institution.

When the patient arrived at our institution, approximately 2 hours after the event, his Glasgow coma scale was eye response, 1; verbal response, not testable; and motor response, 3. Right-sided myoclonus was identified. The cranial nerve exam was remarkable for absent pupillary response, bilaterally. The deep tendon reflexes were normal (2+), bilaterally. The patient’s blood pressure was 153/69 mmHg (MAP: 97); pulse, 90 beats per min; and oxygen saturation, 100% (on mechanical ventilation).

The noncontrast-enhanced head computed tomography (CT) scan performed the day of admission demonstrated multiple foci of gas throughout the subarachnoid spaces of the right cerebral hemisphere (Figure 1). Given the patient’s CT findings and clinical history, the main diagnostic consideration was iatrogenic cerebral air embolism. We quickly started him on hyperbaric oxygen therapy and the antiepileptic drug levetiracetam to treat involuntary movements, which were suggestive of anoxic myoclonus.

Follow-up noncontrast brain magnetic resonance imaging (MRI) was performed the next day (1 day after admission),

Figure 1. (A) Sagittal and (B) axial nonenhanced computed tomography scan performed the day of admission shows multiple foci of gas in the subarachnoid spaces of the right frontal lobe (yellow circles).
demonstrating gyriform cortical restricted diffusion throughout the right cerebral hemisphere and, to a lesser extent, through the left frontal, parietal, and occipital lobes (Figure 2). Corresponding fluid-attenuated inversion-recovery (FLAIR) hyperintense edema throughout the aforementioned regions of restricted diffusion was detected (Figure 2). In addition, regions of white matter edema were seen throughout the supratentorial compartment, which were more extensive in the right cerebral hemisphere. Foci of susceptibility artifacts throughout the right cerebral hemisphere were visualized, correlating with air emboli; better visualized on previous head CT.

The patient received 48 h of hyperbaric oxygen therapy, with no neurological improvement. A noncontrast-enhanced head CT performed on admission day 3 demonstrated loss of the gray-white matter differentiation involving the entire right hemisphere, left frontal and parietal upper convexities, and left occipital lobes, correlating with hypoxic-ischemic injury and brain edema in these regions (Figure 3).

The patient remained in the intensive care unit for 5 weeks, showing no neurological improvement. Prognosis was discussed with the family and the case was taken to the ethics committee. The family decided to sign do-not-resuscitate and do-not-intubate orders, and the patient underwent withdrawal of life support. He was discharged 1 week later to a nursing home to continue comfort care measures.

**Discussion**

Iatrogenic air emboli during endoscopic procedures are rare, difficult to diagnose, and have a high potential for being severe and fatal. An air embolism develops when air is introduced into the vascular system and can be facilitated with a pressurized air source [3,4]. A disruption of the mucosal barrier is commonly associated in such cases [2]. Prompt recognition of neurologic symptoms after an endoscopic procedure is imperative to reduce mortality [1–3].

Most air embolism cases are associated with endoscopic retrograde cholangiopancreatography, but this iatrogenic event has also been described in several endoscopic procedures such as colonoscopy and esophago-gastroduodenoscopy, as in the case of our patient [2,5]. The present case suggests that the esophago-gastroduodenoscopy procedure performed for gastric...
varices surveillance provoked severe retching that led to the mucosal tear and bleeding, which occurred during the procedure. Already dilated, tortuous, and fragile varices put the patient at an increased risk of upper gastrointestinal bleeding because of his chronic liver disease. Furthermore, the increase in intra-abdominal pressure from retching, along with the added insufflation pressure for better visualization of the tear, produced the pressure gradient necessary to introduce air into the venous circulation. According to the literature, the hypothetical volume of air needed to cause fatal air embolism is around 3–5 mL/kg or a high rate of infusion of 300–500 mL at 100 mL/sec [6]. Patients may present with sudden respiratory distress due to decreased gas exchange at the capillary bed of the lungs [7], one of the mechanisms associated with arterial air emboli. Other pathophysiologic events described in the literature include right-to-left shunting associated with a patent foramen ovale, which accounts for 10% to 40% of cases [8].

Without causal distinction, it is understood that all arterial air emboli result in direct ischemic consequences in end organs due to the vasospastic effects of flow obstruction, which are caused by microbubbles in the arterial system [9]. The microbubbles can also induce platelet aggregation, endothelial dysfunction, disruption of the blood-brain barrier, and brain edema [7]. In the case of our patient, the neurological deterioration, which was evident with a Glasgow coma scale of 4, was highly suggestive that the passage of air into the arterial system led to a cerebral air embolism and consequently the acute ischemia of different brain regions. Given that the brain is highly dependent on oxygen to meet its energy demands, an arterial air embolus can result in failure to meet this requirement, resulting in severe irreversible damage, which highlights the urgency of making a proper diagnosis [7].

The ability to identify the clinical presentation of cerebral air embolism is crucial to having the high clinical suspicion needed to provide appropriate preventive measures while waiting for a definitive diagnosis, thereby minimizing delay in treatment. Donepudi et al. described 41 cases of cerebral air emboli associated with endoscopic procedures that presented with nonspecific neurological symptoms including altered mental status, prolonged sedation after anesthesia, and cerebral edema [4]. Similarly, our patient presented with many of these symptoms, which can be easily confused with a cerebrovascular accident or sedative effects, making diagnosis difficult to attain simply by clinical presentation. This case highlights the importance of attaining rapid diagnostic imaging in such a clinically challenging presentation that demands emergent action and advises the cautious use of sedative therapy while performing such procedures in high-risk patients.

If air embolism is suspected, various steps may improve patient outcomes, such as stopping the use of pressurized air, hyperventilation on 100% oxygen, and placement of patient in the left lateral decubitus and Trendelenburg (head below feet) positions [5,10]. Head CT imaging is emergent once procedural or postprocedural neurological symptoms become apparent, with or without cardiorespiratory instability, in an
at-risk patient. Some authors suggest bedside echocardiography as a safer alternative modality as it can decrease the delay in diagnosis and prompt immediate therapeutic intervention [4]. A head CT scan is highly sensitive to air emboli when it is done in a rapid time frame; when the CT is delayed, air can be quickly absorbed from the vasculature and diagnosis can be missed [11,12]. Most air emboli have been detectable since the American College of Radiology (ACR) established that CT scanners must be able to acquire images with a minimum slice thickness of 2 mm or less [13]. However, the acquisition slice thickness varies depending on institutions’ protocols. The ACR recommends an acquisition slice thickness no larger than 5 mm [13]. Some authors suggest that if the CT scan fails to detect the macroscopic air bubbles, diffusion-weighted MRI can be obtained to show early ischemic changes, which are apparent in less than 20 minutes [9].

On noncontrast head CT, a cerebral air embolism is diagnosed by identifying serpiginous air densities throughout the subarachnoid spaces and parenchyma. The air densities can be identified at venous or arterial structures, so it is always important to examine the venous sinuses and the course of the main cerebral arteries. Arterial and venous air emboli usually affect the frontal and parietal lobes. However, it has been described that in arterial air emboli, punctate air emboli can be found in the brain parenchyma, trapped in arterial capillaries [14]. Most patients with a clinical suspicion of ischemic stroke require a noncontrast brain MRI. Most stroke protocol MRI includes T1-weighted, T2-weighted, FLAIR, diffusion-weighted imaging (DWI), and susceptibility-weighted imaging (SWI). DWI is the most important sequence because it reveals early ischemic changes with a sensitivity of 90% and specificity of 97% [15]. SWI is a sequence used to detect hemorrhage. However, it is well known that air can be a magnetic susceptibility source, resulting in a blooming artifact. This blooming artifact is particularly helpful in detecting microbubbles, as in our case [16]. Additional findings related to ischemic changes include edema, which produces high signal intensity on T2-weighted and FLAIR images.

In the case of our patient, emergent noncontrast-enhanced CT imaging supported the clinical suspicion that cerebral air emboli occurred during the esophago-gastroduodenoscopy procedure. The imaging demonstrated multiple gas foci throughout the subarachnoid spaces of the right cerebral hemisphere, which correlated with the brain MRI done a day later. Once clinical suspicion is supported by imaging, treatment should not be delayed. Our patient was quickly started on hyperbaric oxygen therapy, which decreases morbidity and mortality in patients if given within 24–30 h, preferably [7,17,18]. The treatment consists of 100% oxygen at above sea level pressure with a target arterial oxygen level higher than 2000 mmHg [19]. Hyperbaric oxygen acts by compressing and diffusing air bubbles to decrease the ischemic period and provide oxygenation to the hypoxic tissues through high arterial oxygen concentrations [6,19]. This therapy has demonstrated a reduction in mortality from higher than 90% in untreated patients to 7% in patients receiving hyperbaric oxygen therapy [1,9]. However, researchers estimate that if the embolus is larger than 50 mL, treatment may be ineffective [6].

Our patient’s neurological status was severely affected even after hyperbaric oxygen treatment, and the patient was later discharged for hospice care with a poor prognosis. We can hypothesize that air emboli volume was too large for the hyperbaric therapy to be effective. Similarly, Eoh et al. presented a case report of iatrogenic air embolism after upper endoscopy in a patient with no mucosal tears prior to the procedure that was treated immediately with hyperbaric oxygen. As in our case, the patient showed no improvement in neurological status, and a post-treatment head CT scan showed a large right cerebral hemispheric infarction, which also resulted in hospice care [20].

A cerebral air embolism can cause detrimental and irreversibly catastrophic damage in a patient’s neurological function. A recent retrospective study reported that the case fatality rate of air embolism is 15.4%, and that the risk of inpatient mortality was much higher in patients with comorbidities [2]. Our patient presented with a previous history of alcoholic cirrhosis, portal hypertension, and esophageal varices, which increased his risk for such a diagnosis and for a poor outcome after treatment, when compared to other patients with no comorbidities. The literature also showed that air emboli is an independent predictor of mortality [2], which is why early diagnostic imaging is crucial to identify the cause of potential mortality in these patients and accelerate treatment to alleviate the extent of nonreversible neurological damage, although the majority of patients can persist with some neurological deficits [12].

Bai et al. described the case of a patient with liver cirrhosis due to chronic hepatitis C infection who presented with hematemesis and underwent an endoscopic variceal ligation. During the procedure, the patient had a generalized convulsion and became hemodynamically unstable. The patient died 1 day later in the intensive care unit. Although this patient did not receive hyperbaric oxygen therapy, the case highlights the possible impact in fatality rate due to underlying comorbidities [2,3].

In the case of our patient, an esophago-gastroduodenoscopy procedure for gastric varices surveillance was complicated by iatrogenic air emboli, which could have been easily overlooked in medical practice. However, this case reinforces the idea that cerebral air emboli can happen during an endoscopic procedure and must be suspected in a patient presenting with sudden changes in cognition or neurological deficits during or
after the procedure. Additionally, sedation in high-risk patients should be used with caution, and patients should be followed post-procedure with serial neurological tests to avoid missing clinical signs that could lead to immediate diagnostic imaging and prompt treatment with hyperbaric oxygen to improve patient outcome.

Conclusions

Cerebral air embolism is a rare iatrogenic complication of endoscopic procedures that can result in a fatal outcome. It must be suspected in patients presenting with altered mental status and neurological deficits after an endoscopic procedure. Since clinical presentation can be nonspecific, diagnostic imaging should be a priority early on in order to identify the key features of this iatrogenic event. Timely diagnosis and treatment can improve patient outcome.

Conflict of interest

None.

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