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**Fatal Retrograde Venous Cerebral Air Embolism
and Pneumocephalus as a Complication of
Esophagogastroduodenoscopy**

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Abstract

Retrograde air embolism following endoscopic gastroduodenoscopy is a rare but potentially serious complication. This condition can lead to pneumocephalus due to air migrating into cerebral structures. Post-procedure, patients may present with sudden headache, altered consciousness, and neurological symptoms (1). Even in minimally invasive procedures like endoscopy, this rare complication can result in severe outcomes and thus requires prompt recognition and intervention. This case highlights the importance of clinicians being aware of retrograde air embolism as a possible complication during endoscopic procedures (2). In this case, a 7-year-old girl aspirated a sausage during a sausage-eating contest, resulting in respiratory distress and loss of consciousness. Three days after stabilization, pneumocephalus -possibly due to suspected esophageal injury- was observed following endoscopic gastroduodenoscopy, and brain death was subsequently declared.

Introducing

Air embolism is a rare but serious complication that may arise due to esophageal injury following procedures like endoscopic gastroduodenoscopy. Previous studies have reported cases of cerebral air embolism and pneumocephalus during endoscopic procedures, including esophageal balloon dilatation, endoscopic retrograde cholangiopancreatography (ERCP), and esophagogastroduodenoscopy (EGD). Most cases involved patients across various age groups, with mucosal disruption resulting either from procedural intentions (e.g., biopsy) or pre-existing conditions (e.g., gastric ulcer) (4-6). To our knowledge, only very rare cases of air embolism have been reported during endoscopy for food bolus impaction. Here, we present a fatal case of pneumocephalus, likely secondary to retrograde air embolism during endoscopic food removal, in a patient declared brain dead. This report presents a 7-year-old girl who, after aspirating a sausage, underwent delayed endoscopic intervention. Subsequent imaging revealed retrograde air embolism with pneumocephalus, likely related to potential esophageal trauma during the aspiration incident. The case underscores the diagnostic challenges and severe outcomes associated with this rare complication.

Case Presentation

A 7-year-old girl was brought to the emergency department after choking during a sausage-eating contest. Despite attempts to clear her airway with the Heimlich maneuver, the obstruction persisted, leading to respiratory distress and subsequent loss of consciousness. Upon hospital arrival, she was intubated and stabilized. Initial imaging showed signs of aspiration pneumonia but no air densities in the venous system (Figure 1). A CT scan the following day revealed the foreign body (sausage) obstructing the airway, and an endoscopy successfully removed it.

Despite intervention, the patient did not regain consciousness. The neurological examination conducted the day after the endoscopy revealed a Glasgow Coma Scale (GCS) score of 3, with anisocoric pupils, absent corneal and gag

reflexes, no respiratory effort, and no response to painful stimuli. A brain angiography was performed to assess brain death, revealing air densities in the right parietal emissary veins (Figure 2), the left superficial temporal vein (Figure 3a), the superior sagittal sinus (Figure 3b), and the left internal thoracic vein (Figure 4). Air embolism and bubbles were also observed along with intra-axial and extra-axial pneumocephalus (Figure 5) at follow-up exams. These findings suggested retrograde cerebral air embolism likely secondary to suspected esophageal injury during endoscopic gastroduodenoscopy, as venous air densities were observed only after the procedure. Despite intensive care efforts, brain death was declared.

This case underscores the potentially fatal complications of retrograde air embolism that can follow endoscopic procedures, particularly with esophageal injury, highlighting

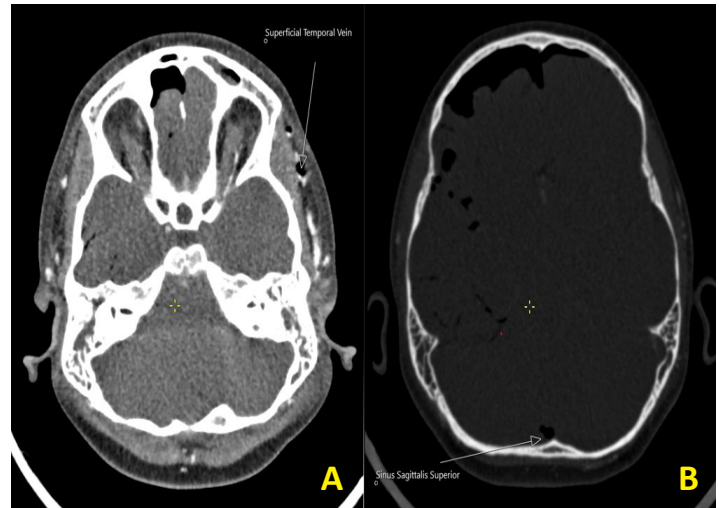


Figure 3: Parenchymal window (a) and bone window (b) enhanced cranial CT showing air densities in the superficial temporal vein (a) and sinus sagittalis superior (b).

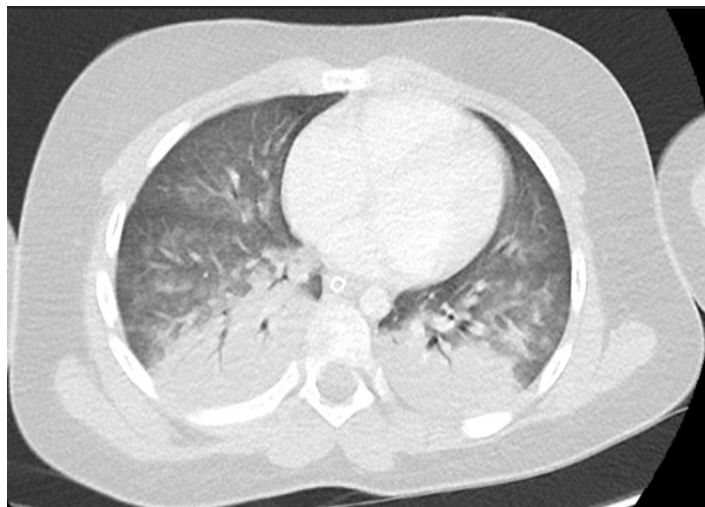


Figure 1: Lung window images of non-enhanced thorax CT. The lower lobes of both lungs demonstrate multiple alveolar infiltrates that coalesce posteriorly, forming areas of consolidation with positive air bronchograms.

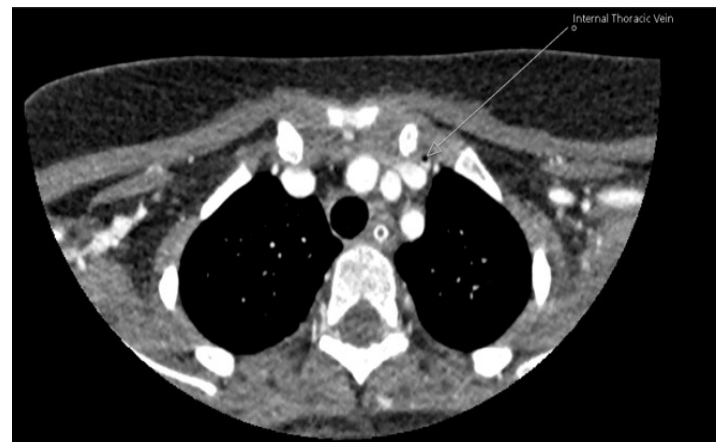


Figure 4: Parenchymal window images of enhanced cranial CT. Air density in the left internal thoracic vein (white arrow).

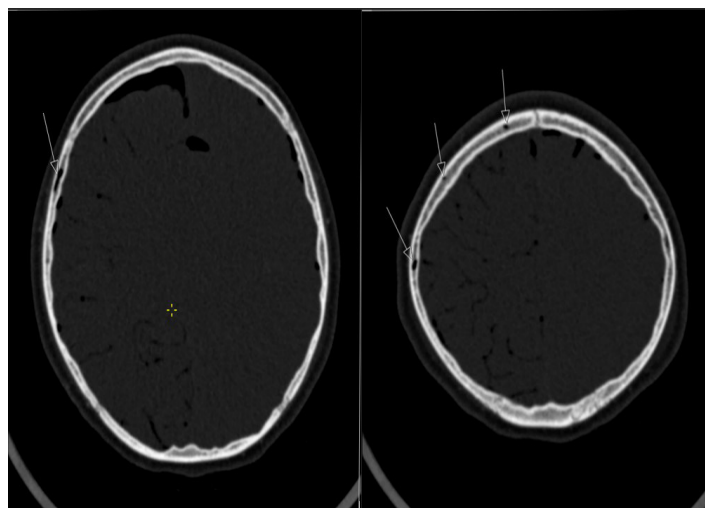


Figure 2: Bone window images of enhanced cranial CT. Air densities in the right parietal bone emissary veins (white arrow) and cerebral sulcal spaces prominent at right cerebral hemisphere.

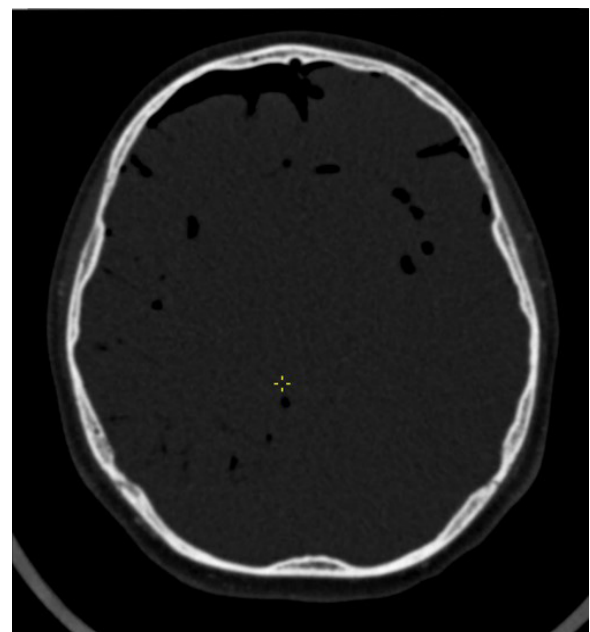


Figure 5: Follow-up bone window images of enhanced cranial CT. Extra- and intraaxial air densities, more prominent on the right with bilateral intra-axial air densities

the serious risks in similar clinical scenarios.

Discussion

Cerebral venous air embolism (CVAE) is a rare but life-threatening complication, with a mortality rate of approximately 25% (7). CVAE typically arises through two mechanisms: paradoxical embolism and retrograde venous air embolism. Paradoxical embolism involves the transfer of air from venous to arterial circulation through right-to-left cardiac or pulmonary shunts, such as patent foramen ovale or pulmonary arteriovenous malformations. However, paradoxical embolism can also occur without such shunts if factors like a large intravascular air volume or vasodilators impair the pulmonary capillaries' ability to filter air bubbles. In retrograde venous air embolism, air within the venous system moves backward, reaching cerebral vasculature against normal venous blood flow (7).

Experimental studies indicate that conditions such as a supine position, venous valve insufficiency, or increased venous pressure in the right heart chambers facilitate retrograde air flow (7). In this case, retrograde air embolism likely resulted from esophageal injury sustained during endoscopy, allowing air entry into the venous circulation, traveling through superficial temporal and emissary veins, and ultimately causing pneumocephalus. Emissary veins, such as the parietal emissary vein, are valveless venous structures that connect extracranial scalp vessels to intracranial dural venous sinuses and diploic veins. Specifically, the parietal emissary vein links the superficial temporal vein branches to the superior sagittal sinus, providing a direct pathway for air or thrombi from extracranial to intracranial venous networks (3). In this case, the absence of any known right-to-left shunt and lack of arteriovenous malformations on chest CT further support the retrograde mechanism as the primary pathway for air embolism (8).

Additionally, conditions like eosinophilic esophagitis (EE)—linked to chronic inflammation and esophageal wall weakening—may increase the risk of injuries during endoscopy, particularly in patients with mucosal disruption (1). This weakened esophageal structure may be more vulnerable to perforation and air entry during procedures involving balloon dilation or prolonged insufflation.

Radiographic imaging, especially cranial computed tomography (CT), is critical in diagnosing CVAE, as cerebral venous air embolism can rapidly lead to severe neurological impairment. Typical CT findings include air in the cavernous sinuses, venous sinuses, or even cortical gyral patterns (8). In this case, air was identified within the parietal emissary veins, superior sagittal sinus, and superficial temporal and internal thoracic veins, consistent with a retrograde air embolism pattern. This case underscores the unique presentation of retrograde air embolism and

pneumocephalus, contributing to the limited literature on such complications following EGD. Immediate recognition and management of CVAE are essential for preventing rapid neurological deterioration, as demonstrated by this patient, who ultimately progressed to brain death.

Conclusion

Retrograde air embolism is a rare but potentially fatal complication following endoscopic procedures like esophagogastroduodenoscopy (EGD). This case illustrates how potential esophageal mucosal injury during endoscopy may lead to air entering the venous circulation, resulting in retrograde air embolism and pneumocephalus. In patients showing sudden neurological decline post-endoscopy, pneumocephalus should be considered, and urgent cranial CT imaging is warranted.

Forensic pathologists should recognize pneumocephalus and air embolism as possible causes of injury or death in patients with esophageal trauma, including that from EGD. Early recognition and intervention in similar cases can be life-saving, emphasizing the need for vigilance in patients exhibiting neurological symptoms post-endoscopy. Awareness of this rare but severe complication is crucial for timely intervention and accurate diagnosis, essential in both clinical management and forensic evaluation.

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