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Visual Case Discussion

Iatrogenic cerebral venous air embolism from peripheral venous catheterization in an elderly patient: A case report

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1. Discussion

This section is meant to put the case into the context of similar cases, to explain specific treatment decisions, and to share additional relevant information that is not included in the case presentation.

Iatrogenic vascular air embolism (VAE) is a relatively infrequent, but serious event associated with significant morbidity and mortality, even id diagnosed promptly. While traditionally associated with neurosurgery, cardiac surgery, and (liver) transplantation surgery, recent increases in the incidence of VAE have been linked to hemodialysis, thoracentesis, angiography, and central and peripheral venous catheter placement and removal. The expansion of interventional radiology (IR) has also contributed to this rise, with a reported frequency of approximately 0.13 % in IR procedures.[1]

VAE can result in both venous and arterial emboli, with the clinical course dictated by the size and anatomical location of the embolus. The coronary and cerebral circulation have the highest potential for adverse consequences even if the emboli are small. Cardiac signs include circulatory collapse, hypotension, bradycardia, tachycardia and chest pain, while neurologic symptoms include focal neurological deficits, seizures, loss of consciousness, confusion and altered mental status.[2] The obstruction caused by air emboli also triggers immediate pathoanatomic, immunologic, and thromboinflammatory responses at the endothelial level.[1] In the venous circulation, smaller volumes of air (less than 50cc) may be absorbed by the pulmonary filtration system without causing a pathological response.[1] However, anatomic heart defects that allow for right-to-left shunting, such as a patent foramen ovale, can enable air emboli to bypass the pulmonary filtration system and enter the arterial circulation[2].

Larger volumes of gas in the venous system can cause an obstruction in the pulmonary circulation, potentially leading to serious consequences. Air entry in vessels proximal to the right ventricle decreases the volume of air required to cause fatal consequences. These symptoms tend to more non-specific and include dyspnea, continuous coughing, chest pain, and a sense of "impending doom".[2] Gravity also plays a role in emboli movement, and emboli that remain in the venous circulation may also travel retrogradely towards the patient's head while in a sitting position. This is due to the buoyancy of the gas bubble overcoming slow antegrade venous blood flow. This was the case in our visual case discussion.

The initial management of a suspected VAE includes 100 % oxygen supplementation by non-rebreather mask (NRM), stopping further air entry, and positioning the patient in the Trendelenburg and left lateral decubitus positions, known as Durant's maneuver.[3] This maneuver helps to trap the air in the right ventricle and prevent it from entering the pulmonary artery, thereby reducing the risk of a fatal outcome. Following this, aspiration of air from the right ventricle should be performed only if a thoracic central venous catheter is in use and placed correctly.[3]

For larger volumes of air or if initial treatment is insufficient, hyperbaric oxygen therapy (HBO) is the subsequent required intervention.[3] HBO influences the inverse relationship between air bubble size

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and atmospheric pressure to reduce the volume of the embolus and improve oxygenation. Additionally, increased oxygen supplementation, whether by NRM or HBO, accelerates absorption of nitrogen from the air embolus. Recompression and HBO administration are also potential life-saving therapies, especially in cases of air embolism related to underwater diving.[3]

Vascular air embolism, though rare, can lead to sudden cardiac death and other severe outcomes. Early recognition and intervention are crucial for improving prognosis. High-risk procedures require a heightened awareness to facilitate prompt diagnosis and life-saving treatment is warranted. Effective management strategies, including 100 % oxygen supplementation via NRM, the use of HBO and appropriate patient positioning, are essential to mitigate the potentially fatal consequences of this complication.

2. Visual case discussion

This is the body of the submission. The case discussion presents a description of the clinical scenario associated with the figure(s) / video(s). This should be a maximum of 1,000 words.

An 82-year-old female presented to the emergency department via ambulance services after a rapid decrease in vision. The symptoms started three days prior to her presentation and were accompanied by severe headache and jaw pain. The patient had significant medical history, including pulmonary emphysema, hypertension, atrial fibrillation, myocardial infarction and heart failure. Her medications included apixaban, digoxin, metoprolol, barnidipine, pantoprazole and isosorbide mononitrate.

She was transported in the upright sitting position and received a peripheral venous catheter on the dorsal surface of her left hand. The patient did not receive any medications, but the catheter was flushed with 5mL of a BD PosiFlush™ SP Prefilled 0.9 % Saline Syringe.

Upon arrival, her vital signs showed oxygen saturation at 96 % on room air, atrial fibrillation with a variable rate of 60-120/min, blood pressure at 183/96 mmHg, and a blood glucose level of 6 mmol/L. The neurological examination revealed the following: the right eye's direct reflex was absent while the indirect reflex was present; the left eye's direct reflex was present while the indirect reflex was absent. Vision in the right eye was decreased with altitudinal vision loss. All other neurological tests were normal, but there was a palpable thickening of the right temporal artery. A brain CT scan was performed that revealed no hemorrhage or signs of recent ischemia. However, there was the presence of an air configuration in the superior sagittal venous sinus (Fig. 1A-C). Laboratory results showed an erythrocyte sedimentation rate (ESR) of 33 mm/hour, C-reactive protein (CRP) of 46 mg/L, and normal renal, liver, and hematologic tests.

Given the negative findings for stroke on the CT scan and a clinical presentation suggestive of temporal arteritis with ocular dissemination, the patient received an initial dose of 60 mg prednisolone. She was then sent for confirmatory testing. A duplex ultrasound of the temporal arteries showed a halo sign, supporting the diagnosis of temporal arteritis. The patient was urgently referred to rheumatology and ophthalmology. The ophthalmologist confirmed arteritic anterior ischemic optic neuropathy in the right eye, and the patient was given a 3-day course of high-dose methylprednisolone.

While the clinical diagnosis of temporal arteritis was evident, the incidental finding of an air configuration in the superior sagittal venous sinus on the CT scan raised concern. The patient had not received any recent surgeries, central venous catheters, or been exposed to barotrauma. It was discovered that an unprimed BD PosiFlush™ SP Prefilled Saline Syringe (Fig. 2) was used in the prehospital ambulance setting, likely introducing a small volume of air into the venous system. Each prefilled syringe for flushing venous catheters in the unprimed setting contains 0.5 mL of air that needs to be primed before use. Given the small volume of air, a watchful waiting approach was adopted. The patient was closely monitored, and the Durant position was not necessary due to the absence of symptomatic air emboli. A repeat CT scan was planned to ensure the air embolism resolved.

Following the initiation of high-dose corticosteroids and specialist interventions for the temporal arteritis, the patient made a near full recovery with only slight residual vision loss in her right eye. Follow-up CT brain 2 weeks later showed the resolution of the previously noted air configuration in the sagittal venous sinus, confirming the transient nature of the cerebral venous air embolism. The patient's management involved a multidisciplinary approach, emphasizing the roles of emergency physicians, neurologists and ophthalmologists in addressing both the temporal arteritis and the incidental cerebral venous air embolism.

3. Caption for image(s) or video(s)

Upload image(s) and / or video(s) separate from submission template

- You may repeat the article title as a figure legend, if appropriate. Keep the figure legend brief but relevant so that the image(s) can show up in searches.
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- If your image has arrows or other identifiers, be sure to state in the legend specifically what the identifier is calling out.
- For additional information, refer to image / video guidelines in the Guide for Authors.

4. References

There is a minimum of 1 and a maximum of 3 references. There are no

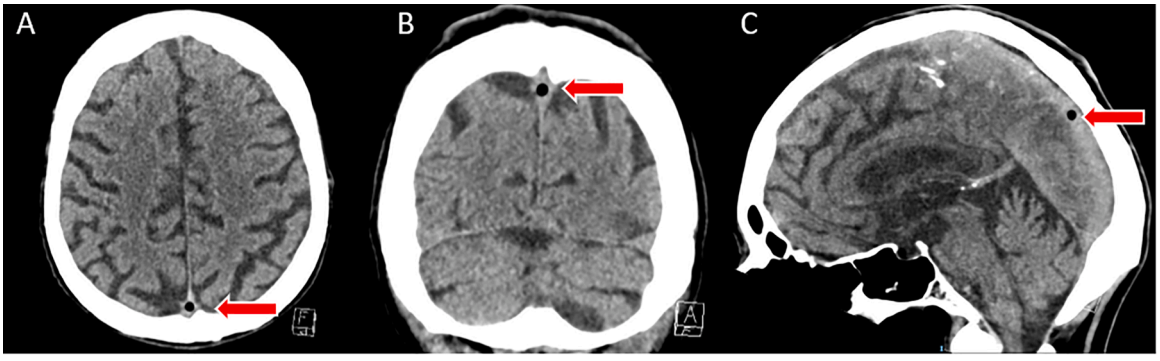

Fig. 1. Non-contrast enhanced CT brain images with axial (a), coronal (b) and sagittal (c) views: Demonstrating a single air embolus in the superior sagittal sinus (red arrow).

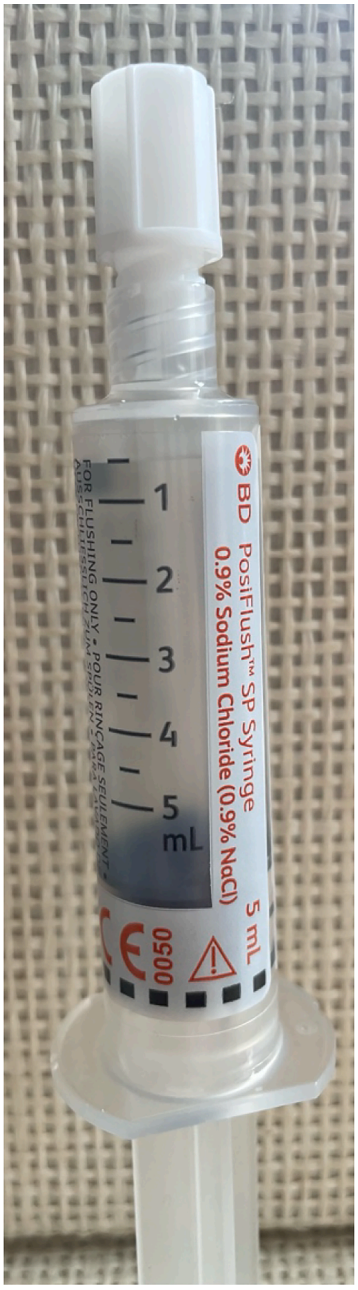

Fig. 2. Figure of a standard unprimed BD PosiFlush™ SP Prefilled Saline Syringe used by the pre-hospital ambulance service. Note the 0.5cc of air in the syringe.

strict requirements on reference formatting at submission. References can be in any style or format as long as the style is consistent. Wikipedia and similar websites may not be used as references. Where applicable, author(s) name(s), journal title / book title, article title / chapter title, year of publication, volume and issue / book chapter, and the pagination must be present. Use of DOI is highly encouraged. The reference style used by the journal will be applied to the accepted article by Elsevier at the proof stage. Note that missing data will be highlighted at proof stage for the author to correct.

5. Questions and answers with a brief rationale

True & false and / or multiple-choice questions

- **Tips**: The questions may address issues of etiology, clinical presentation, differential diagnosis, diagnostic testing, natural history of disease, risk factors, management / treatment, potential complications, patient disposition, or other subjects pertinent to pre-hospital and hospital-based emergency medicine healthcare providers. Additional question writing guidelines can be found here.
- **Note:** You will have an opportunity to review the questions and answers before submitting your completed article. The questions and answers will not be a part of the final author proof. The questions will appear alongside your article in a test format.

5.1. Question 1

Question Type (please choose one option) multiple choice
Question Text (max. 160 characters) or *Caption Text* (if image) (max. 500 characters)
What is the most common cause of venous air emboli?
Answer Options

a) Central venous catheterization
b) Peripheral venous catheterization
c) Pulmonary barotrauma
d) Neurosurgery
e) Intervention radiology procedures

Correct Answer = a
Explain why this is the correct answer (max. 500 characters)
This is most commonly associated with central venous catheterization, as the potential for negative pressure exists in the thoracic vessels due to respiration.
Reference: Puri VK, Carlson RW, Boner JJ, Weil MH. Complications of vascular catheterization in the critical ill. A prospective study. Crit Care Med. 1980; 8:495–9. [PubMed: 7418424]
If supporting information for this question is not in the article itself, please specify authoritative source(s). For example, through citation of a publication, or reference to handbook or clinical practice guideline

5.2. Question 2

Question Type (please choose one option) multiple choice / image
Question Text (max. 160 characters) or *Caption Text* (if image) (max. 500 characters)
What is the accepted emboli size to be considered mortal?
Answer Options

a) 10-50 cc
b) 100-150 cc
c) 200-250 cc
d) 300-500 cc
e) 700-900 cc

Correct Answer = d
Explain why this is the correct answer (max. 500 characters)
The lethal volumes of air in an acute bolus have been described and are approximately 0.5–0.75 ml/kg in rabbits and 7.5–15.0 ml/kg in dogs. The lethal dose for humans has been theorized to be 3-5 ml/kg and it is estimated that 300-500 ml of gas introduced at a rate of 100 ml/sec is a fatal dose for humans.
If supporting information for this question is not in the article itself, please specify authoritative source(s). For example, through citation of a publication, or reference to handbook or clinical practice guideline.

- Gordy, S., & Rowell, S. (2013). Vascular air embolism. International journal of critical illness and injury science, 3(1), 73-76. DOI: 10.4103/2229-5151.109428

CRediT authorship contribution statement

V. W. Klokman: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **T. J. A. Schönberger:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us. We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property. We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript. The patient has consented to the submission of the case report for submission to the journal. The radiological images accompanying the submission are anonymized, and the case report does not contain information that may identify the patient. We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). He/she is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the Corresponding Author, and which has been configured to accept email from vklokman@gmail.com.

References

1. Marsh PL, Moore EE, Moore HB, Bunch CM, Aboukhaled M, Condon SM, Walsh MM. Iatrogenic air embolism: pathoanatomy, thromboinflammation, endotheliopathy, and therapies. *Front Immunol.* 2023;14, 1230049. https://doi.org/10.4103/2229-5151.109428.
2. McCarthy CJ, Behravesh S, Naidu SG, Oklu R. Air embolism: diagnosis, clinical management and outcomes. *Diagnostics*. 2017;7(1):5. https://doi.org/10.3390/diagnostics7010005.
3. Gordy S, Rowell S. Vascular air embolism. *Int J Crit Illn Inj Sci.* 2013;3(1):73–76. https://doi.org/10.4103/2229-5151.109428.