Massive air embolism while removing a central venous catheter

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ABSTRACT

Air embolism is a rare but mostly iatrogenic complication of medical or surgical procedures and may have a serious outcome. On the removal of a central venous catheter (CVC), minor carelessness can lead to a venous air embolism sometimes accompanied by arterial embolism. We experienced the case of a 61-year-old male who suffered from a paradoxical systemic air embolism while we removed a CVC. Immediate resuscitation and venovenous extracorporeal membrane oxygenation support saved his life. Multiple end-organ damage related to the systemic air embolism was noted, including the kidney, liver, and brain. In echocardiography, multiple air bubbles and an atrial septal defect were observed. An air embolism is preventable with appropriate precautions and techniques. Therefore, it is important to identify errors and prevent occurrence.

Key Words: Air, atrial, brain infarction, embolism, heart septal defects, resuscitation

INTRODUCTION

The placement of a central venous catheter (CVC) is a common medical procedure in the treatment of many critically ill patients but is associated with infectious, thrombotic, and mechanical complications.1 Air entry into the venous circulation related to a CVC is a rare but potentially lethal complication. A paradoxical arterial embolism may occur when a shunt is present or when a large volume of air is administered.2 A systemic embolism can cause ischemic end-organ damage, with the brain and heart most vulnerable to ischemia and associated with poor prognosis. Herein, we report a case of a massive systemic air embolism after removal of a CVC, with interesting images associated with the air entry. Specifically, in this case, we used extracorporeal membrane oxygenation (ECMO) to save patients. The report was approved by the hospital’s institutional review board, and the requirement for informed consent was waived because of single case report.

CASE REPORT

A 61-year-old male visited another hospital with acute abdominal pain and fever. He was diagnosed with a perforated duodenal ulcer and sepsis. He was treated with primary surgical closure, and right internal jugular vein catheterization was performed in the operating room. After 5 days of intensive care unit treatment, the patient was stabilized and transferred to a general ward. On the 6th postoperative day, the CVC was removed by a physician assistant. The procedure was performed in a sitting position. A few seconds after removal of the catheter, the patient abruptly complained of shortness of breath and chest discomfort and became unconscious. Immediate cardiopulmonary resuscitation was performed, and the return of spontaneous circulation was achieved 5 min after the collapse. A transthoracic echocardiogram revealed multiple air bubbles in the right and left ventricles and an ostium secundum atrial septal defect measuring 0.5 cm with a right-to-left shunt [Figure 1]. Air embolism was strongly suspected, and brain and chest computed tomography (CT) were performed simultaneously. Brain CT showed gas within the centrum semiovale, cerebral sulci, and cavernous...
sinuses; and free air was observed in the neck, jugular vein, and left ventricle on chest CT [Figures 2 and 3].

He was transferred to our hospital afterward, and his vital signs on arrival were blood pressure of 107/75 mmHg, heart rate of 134 beats/min, respiratory rate of 30 breaths/min, and temperature of 35.8°C. Glasgow coma scale was 3/15 without brain stem reflex. Chest X-ray showed extensive bilateral infiltrates consistent with pulmonary edema. An initial arterial blood gas analysis while he was being mechanically ventilated with a FiO$_2$ of 1.0 showed a pH of 7.141, PaCO$_2$ 52.3 mmHg, PaO$_2$ 53.6 mmHg, HCO$_3$–14.8 mEq/L, and SaO$_2$ 74%. Therefore, venovenous ECMO support was employed through both femoral veins.

The patient was gradually stabilized, and pulmonary edema and lung injury were ameliorated. As a result, the patient was successfully weaned off ECMO support on the 7th hospital day. On the follow-up echocardiography performed on the 3rd day of ECMO support, ejection fraction of the left ventricle was preserved, and no regional wall motion abnormalities were observed. An apical left ventricle thrombus was newly observed, and anticoagulation therapy was started. Acute renal failure was also present but improved without hemodialysis. However, the patient did not recover consciousness above a Glasgow coma scale score of 9, and diffuse cerebral ischemia was observed on the brain magnetic resonance imaging. The patient underwent a tracheostomy and was transferred to the general ward.

**DISCUSSION**

Among the many clinical threats that are related to CVC, embolism is rare but catastrophic. Air can enter the vascular system at the time of catheter insertion or removal and during accidental disconnection of catheter. A large volume of air can enter the vascular system in a short period of time. A pressure gradient of only 5 mmHg across a 14-gauge catheter can entrain air at a rate of 100 mL/s, and this is enough to produce a fatal venous air embolism.\[3\] Pressure gradients may become larger with the patient in a sitting position, during inspiration, and in the hypovolemic state. Therefore, to avoid air embolism, the position of the patient and cooperation during CVC removal are critical. However, even these simple guidelines are often not followed well in clinical practice. Ely et al.\[4\] reported a significant number of physicians (13.9%) elevated the head of the patient’s bed to remove a catheter. In rare cases, air can enter through a track associated with a long-drawn catheter or through gauze dressing after removal.\[5\] Therefore, it should be ensured that the exit site of the catheter is covered with an ointment-based air occlusive dressing and that pressure is applied afterward for 5–10 min.

Arterial air embolism may also occur in association with venous air embolism. First, the paradoxical embolization of air moves through a septal defect, patent foramen ovale, or pulmonary arteriovenous malformation. In patients with a left-to-right shunt, significant volumes of air in the pulmonary circulation can raise pressure in the right heart and reverse the direction of the shunt, also allowing paradoxical embolism to occur.\[6\] Second, a large quantity of air can disturb filtration of the pulmonary capillary system, which allows the air to spill over into the arterial circulation without the presence of a shunt.\[7,8\]

Systemic arterial emboli usually occlude microcirculation and cause ischemic end-organ damage. In particular, the brain and heart are the end organs most vulnerable to these ischemic events, which can lead to irreversible sequel or death. The air emboli cause pathological changes by two mechanisms: a reduction in perfusion distal to the...
obstruction and an inflammatory response.\textsuperscript{[2]} Microbubbles of air are associated with local endothelial damage and a foreign-body response through cellular and humoral immune mechanisms. These processes lead to vasogenic edema and worsen ischemia of the end organs.\textsuperscript{[9]}

The initial treatment of air embolism is to prevent further entry of air and maintain vital functions. Theoretically, hyperbaric oxygen therapy is the only direct treatment that can be considered, especially for arterial air embolism. Pure oxygen with higher atmospheric pressure may not only decrease the size of air bubbles but also provide an adequate supply of oxygen to the ischemic tissue. Early hyperbaric oxygen therapy within 6 h may improve the prognosis of the patient, but to our knowledge, no controlled study has been conducted.\textsuperscript{[10]} Such a treatment can be performed only in some specialized centers, and hemodynamically unstable patients who really need treatment are often unable to enter the treatment space. There is no evidence that treatment with corticosteroids, anticoagulants, or lidocaine is related to a beneficial outcome.\textsuperscript{[2]}

As an advanced treatment option, ECMO can be considered in patients with intractable hypoxia or shock. Air embolism associated with catheter removal can be a serious medical problem because it is mostly an iatrogenic accident and occurs when the patient improves. Therefore, as in our patient, treatments such as ECMO may be performed when a bad prognosis is expected. Careful attention of physicians to prevent air embolism related to CVC is of utmost importance.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the journal. The patient understands that name and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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