Air Embolism

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Injury/Disease Demographics

- Air embolism is the introduction of air into the vascular system, either venous or arterial, that can result in significant pathology depending upon the location of embolization.
- In the hospital, it most commonly occurs during surgery or vascular procedures (central venous catheters, angiography) and occurs either through direct introduction of air or through a pressure difference.
    - Procedures including bronchoscopy, colonoscopy and dental and ophthalmologic procedures also are at risk for air entry.
    - A high degree of suspicion for gas embolism must be maintained if a patient has a sudden acute decompensation during laparoscopy, as there is a constant source of carbon dioxide under pressure.
    - The more common procedures are neurosurgical and otolaryngological, as these patients are positioned at times prone or sitting.
- Injuries to large blood vessels (arteries or veins) in any part of the body (such as jugular, subclavian, or femoral veins, or carotid arteries for example) with communication to the atmosphere can result in entry of air into the circulation. Both blunt and penetrating trauma can cause this via a laceration from a bone fragment or a missile.

Clinical Presentation

- Air in the vascular system travels to a point where it cannot dissipate and causes obstruction of blood flow, similar to a pulmonary or fat embolus.
- An air embolism may present with neurologic changes, hypoxia, or arrhythmias if it enters the cerebral, pulmonary, or coronary circulation, respectively. All organs are susceptible, but those are the ones with most immediate and devastating effects.
- Penetrating trauma to the hilar region of the lung are at high risk due to the proximity of the pulmonary vasculature to airway structures. The classic presentation is cardiac arrest following intubation and positive pressure ventilation.
- If air enters the venous circulation, and there is a Patent Foramen Ovale (PFO), the air can traverse into the arterial circulation and embolize to the coronary or cerebral circulation.

Evaluation/Diagnostics/Imaging

- Patients with penetrating thoracic trauma may demonstrate tachyarrhythmias and the EKG may demonstrate a right heart strain and/or ST-T changes, indication of air in the coronary circulation.
- CT scans with IV contrast of the affected area (brain, chest), may show lack of flow and an embolus in the associated artery or vein.
- Echocardiography is useful to not only demonstrate cardiac function but also pulmonary hypertension or right atrial dilation in the presence of a pulmonary air embolus. This can be demonstrated by findings suggestive of a “washing machine,” or “millwheel” which is a turbulent flow superimposed with a swishing roar. With large volume of air, a drum-

like murmur may develop. A bubble study in echocardiography can also demonstrate the presence of a patent PFO to determine if the patient had a potential cross-over of air. Generally 1 mL of air in 9 mL of saline is injected via a central line and the ultrasound probe is used to detect crossover from the right side of the heart to the left (so-called bubble test). These findings then should raise the awareness of embolism to the general circulation (coronary, cerebral, etc.).

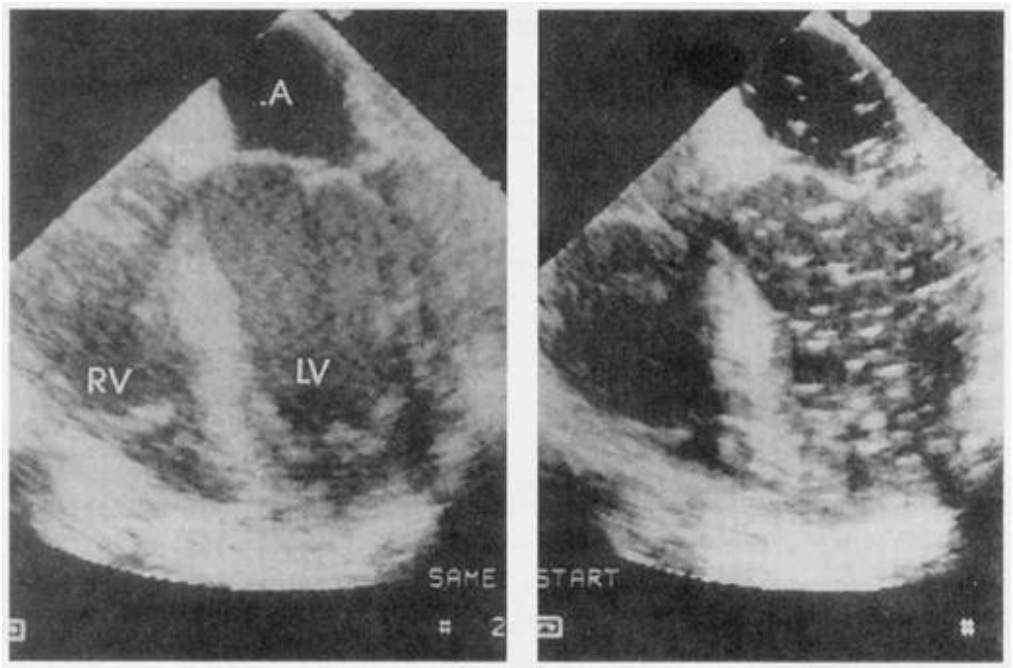

Fig 1. TEE from a trauma patient with air embolism on mechanical ventilation. First panel shows a four chamber view during apnea and the second panel demonstrates air in the left ventricle and atria during positive pressure ventilation. (2)

Role of Conservative Management/Indications for Operative Intervention

- Supportive treatment is key initially if the patient is symptomatic (respiratory and circulatory support), and if diagnosed with an air embolism the patient should be placed in the supine position with the head lower than the heart to contain the air embolism in the heart (air/fluid level at superior aspect of right or left ventricle) in an attempt to limit propagation into the pulmonary or general circulation.

Figure 2. Durant maneuver (left lateral decubitus position with head down)

- A patient with a venous embolism as documented by echocardiogram, should be placed in the left lateral decubitus position with the head down (Durant maneuver) to prevent further migration by keeping the air in the atria and preventing migration into the circulation.
- If the patient is critically ill, supportive treatment in the ICU is warranted and mechanical ventilation and/or vasopressor therapy initiated as needed.
- Although there are no randomized control trials to support the use, there is some data with good outcomes to support the use of hyperbaric oxygen (HBO) on stable patients with air embolism. This has been demonstrated with patients with air emboli from SCUBA diving and iatrogenic emboli from procedures that are hemodynamically stable. HBO is not widely available and unless ground transport is available, transfer is not widely recommended.
- For large amounts air in the intravascular circulation causing outflow obstruction not relieved by positioning, central catheter based treatments of aspirating air can be tried as well if proper resources are available (cath lab, or a PA catheter and an echocardiogram).
- Anticoagulation is not of benefit.

Intra-operative Considerations

- In the trauma patient, any vascular injury, especially venous injury, needs to be adequately secured to prevent air entry.
- If there is penetrating chest trauma with sudden circulatory collapse after intubation and positive pressure ventilation occurs, rapid access to the penetrating injury via a resuscitative thoracotomy is crucial.
- Clamping of the pulmonary hilum is a maneuver that can prevent further entrapment of air in the circulation, and if air is suspected in the ventricle it can be aspirated with a needle
- Air can also enter the coronary circulation, which can be ameliorated with massaging the ventricles and artery.

- After return of spontaneous circulation, maintaining the patient in Trendelenburg is of benefit until the injury is addressed and controlled.

Suggested Readings

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