Air Embolism
What Every Patient (and Parent) Should Know
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Air Embolism: What is It?

Air Embolism

When an air mass enters a vein, it’s called a venous air embolism. When an air mass enters an artery, it’s called an arterial air embolism.

An Air Embolism can travel to your brain, heart, lungs or other organs. If it blocks a vessel, it can cause a heart attack, stroke, or respiratory failure leading to mortality or significant complications.

Air Embolism is a preventable event that can put patients at great harm.

Venous Air Embolism is thought to be more common than arterial Air Embolism.
Air Embolism

How Does It Happen?

Injuries from Air Embolism would be virtually non-existent but for medical and surgical procedures. Air Embolism that is the result of medical intervention is called iatrogenic air.

Through IV Lines

Air can invade your IV or other type of fluid line in a variety of ways.

- Improperly de-aired fluid bag.
- When a fluid bag is changed.
- Through “ports” in the line where medication is injected.
- Through various medical devices including devices used to warm the fluid (fluid warmers) and devices to control flow (infusion and syringe pumps).
- During an IV insertion or removal.

Certain Procedures

Certain surgical procedures increase the risk for both arterial and venous air embolism. These surgeries including laparoscopic, arthroscopic and hysteroscopic procedures as well as gastrointestinal endoscopes that use liquid, air or gas (usually carbon dioxide) to improve visualization during the procedure.
Air Embolism

Why Is It Dangerous?

Our vascular system is a closed system. Air masses do not naturally occur in our veins and arteries and can cause significant damage by their presence.

Air is a foreign body in our bloodstream.

There has been a bias in the medical community that the body can “tolerate” small amounts of air and that the lungs will “filter it out.” There is now a growing body of evidence, however, that even small amounts of air can cause significant damage to the blood vessels and organs. This research shows that every time air is allowed to enter a patient’s circulation, harm is caused.

- Once an air mass enters the bloodstream, it is immediately attacked and treated like any other foreign substance that enters our body and triggers our natural defense mechanisms.
- Invading air masses are immediately coated by platelets, white blood cells and other proteins as they travel through our bloodstream.
- While they travel, they can damage or degrade delicate lining of our blood vessels (called endothelial glycocalyx and its underlying endothelial cells) resulting in endothelial cell edema, inflammation, localized platelet and white cell activation and even blockages in the tiny pulmonary capillary vessels.
- The normal size of our capillaries (microcirculation) is somewhere between 4-9 microns in diameter (a strand of human hair is about 100 microns wide by comparison) but the air masses trying to pass through these capillaries can be hundreds or thousands of microns larger.

Luckily, with today’s technology, there is no reason that even small amounts of air should be allowed to enter a patient’s body to do damage.
Patients with congenital heart defects or anomalies

Patients with congenital heart defects or anomalies need to be especially vigilant as small amounts of air can cause a catastrophic stroke or other significant Neurological event. A Venous Air Embolism will enter eventually enter the right side of the heart and would normally be sent to the lungs for oxygenation. It would then come back to the left side of the heart for circulation to organs and tissues. In a normal heart, there is a septum that separates the left and right sides of the heart.

However, there are many types of septal defects that allow “shunting” between the right and left sides of the heart (Atrial Septal Defect or ASD, Ventricular Septal Defect or VSD, Tetralogy of Fallot (a combination of complex defects) and Patent Foramen Ovale). These defects allow blood (and Air Emboli) to travel from the right side of the heart to the left side and potentially to the brain through the carotid arteries. Neonates undergoing procedures for heart defects are especially at risk from even minute amounts of air.

25-30% of adults have what is called a PFO or Patent Foramen Ovale, allowing venous air bubbles to cross over to the left side of the heart and up to the brain.

A significant percentage of adults (25-30%) have what is called a PFO or Patent Foramen Ovale. Most PFOs are asymptomatic for long periods of time so most people with a PFO are unaware of it. At birth, we are all born with an opening in the atrial wall of our heart that separates the right side of our heart and the left side of our heart. This opening is called a Foramen Ovale, and usually closes at birth or shortly after. Some Foramen Ovale defects do not close at birth and are thereafter called a Patent Foramen Ovale which often can be detected through radiological exams.

This PFO is estimated to still be present in about 25% to 30% of adults (that’s approximately 1 in every 4 people) and has been reported to be an important risk factor for strokes, cerebrovascular accidents and transient ischemic attacks (TIA’s). Some people know they have a PFO but most do not until the doctor detects it. People generally function well and go through life with a PFO until they get diagnosed on routine examination or develop symptoms.
Even in the absence of a PFO or other defect, microbubbles have the potential to pass from the venous circulation into the left side of the heart through shunts that exist in the lung, called Intrapulmonary Arteriovenous Anastomoses (IPAVA), which are just small blood vessels that do not contact the air sacs in our lungs and therefore allow venous blood (and emboli) to pass directly into the left side of the heart. These IPAVA shunts are known to exist in approximately 30% of resting adults, and have the potential to increase in number in all adults during exercise.

About 25-30% of the general population (about 1 in every 4 people) has the potential for venous air bubbles to cross over to the left side of the heart and up to the brain through the PFO, and > 30% in those people with patent IPAVA shunts.

Significant amounts of air. Accidents are known to be a frequent occurrence in health care institutions. As equipment and treatment protocols have gotten increasingly complex and medical professionals care for an increasing numbers of patients, the potential of mishaps increases. IVs are no exception. Medical errors are the 3rd leading cause of death in the United States. And even at that rate, they are likely under-reported. Devices like those to warm fluids (fluid warmers like the Hotline, enFlow amd Ranger) and to manage fluid volumes (infusion pumps made by Alaris/CareFusion, Baxter and B. Braun) have the potential to deliver air to patients. A growing number of FDA recalls and adverse events related to air in line while using warmers and pumps is an indication of the risk.

When a large bolus of air rapidly enters the venous system, it can cause an airlock in the right atrium and ventricle, causing obstruction of flow from the right ventricle.

The mortality rate for Air Embolism has been reported to be 50% or higher.
Air Embolism

How Can You Be Diligent?

An Air Embolism can be very difficult to diagnose, especially if clinicians are not keenly aware of the various signs and symptoms that may occur with an Air Embolism. There is no hallmark signal of an Air Embolism and many symptoms (memory loss, emotional upset, stroke, heart arrhythmias, trouble breathing) mirror other syndromes.

Before getting an IV inserted, you should ask your medical providers what steps they take to ensure your fluid lines are free of air. Ask if they have implemented devices that monitor your lines and automatically remove air. You should share your concerns if the answer is that “small amounts of air don’t matter.”
Air Embolism

How Will You Know if It Happens?

When air invades our vasculature, it may prevent blood flow and reduce the amount of oxygen and nutrients delivered to the brain and other organs.

Symptoms of Air Embolism

- Decrease in end tidal carbon dioxide (ETCO2) as measured by capnography scores on your anesthesia or intensive care monitors.
- A cardiac “mill wheel” murmur (a loud, churning machinery-like murmur over the heart) can be heard.
- Shortness of breath (dyspnea) and or gasp reflex or wheeze as a result of pulmonary vasoconstriction and bronchoconstriction.
- Shallow, fast breathing (tachypnea) and a sense of doom.
- Altered mental status and cognitive impairment when there is decreased blood flow to the brain.
- Chest pain occurs if the air embolism enters the coronary arteries and causes myocardial ischemia and/or heart attack.
- Increased central venous pressure and increased pulmonary artery pressure occur due to failure of the right ventricle.
- Hypotension and tachycardia (racing heart) result from decreased cardiac output due to right ventricular outflow obstruction which will eventually impede systemic blood flow.
- Electrocardiograph may show peaked P-waves indicating right heart strain.
- Systemic inflammatory response syndrome occurs, leading to increased capillary permeability and potential pulmonary swelling.

Complications from Air Embolism may include cardiac collapse or stroke.
Air Embolism

What are the Treatment Options?

Prevention is Key.
Air Embolism is difficult to diagnose and treatment options are limited. Immediate intervention should include prevention of future air entrapment and hemodynamic support.

Administration of 100% Oxygen
Massive Air Embolism that results in cardiac standstill may be immediately placed on 100% oxygen to maximize oxygenation during cardiovascular instability.

Hyperbaric Oxygen Therapy (HBOT)
Once the patient is stabilized, immediate Hyperbaric Oxygen Therapy (HBOT) is recommended to compress existing air bubbles. HBOT involves the administration of 100% oxygen. This maximizes the patient’s oxygen and reduces the embolus volume by eliminating nitrogen. HBOT involves breathing pure oxygen in a pressurized room or tube. HBOT treatment capability is available in only about 1/3 of US hospitals.

Left Lateral Decubitus Position
Placing patient in the left lateral decubitus position (Durant maneuver) may help prevent embolic obstruction in the heart (air lock).

Aspiration of Air
Aspiration of air from the right atrium may be possible with use of catheters. The Bunnegn-Albin multiforce catheter has been shown to have the highest success rate.

Cardiopulmonary Resuscitation and Chest Compressions
Massive Air Embolism that results in cardiac standstill may be immediately treated with cardiopulmonary resuscitation with defibrillation and chest compression. This may move the air embolus out of the pulmonary tract into smaller pulmonary vessels.

Mortality rate from Air Embolism ranges from 50% to 80%. Morbidity and mortality is related to the volume of air, rate of accumulation, size of the patient, pre-existing health or heart conditions, and position of the patient.

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Air Embolism - a gas bubble trapped within the blood vessels.

Atrial Septal Defect (ASD) - a hole in the septum between the right and left atria.

Cardiac Shunt - A cardiac shunt is a pattern of blood flow in the heart that deviates from the normal circuit of the circulatory system. It may be described as right-left, left-right or bidirectional, or as systemic-to-pulmonary or pulmonary-to-systemic. The direction may be controlled by left and/or right heart pressure, a biological or artificial heart valve or both.

Edema - the medical term for swelling.

Electrocardiograph - Also called EKG, and used in the diagnosis of heart disease. It is a device that detects and records the differences in electric potential caused by heart action and occurring between different parts of the body.

Iatrogenic - resulting from the activity of a health care provider or institution; said of any adverse condition in a patient resulting from treatment by a physician, nurse, or allied health professional.

Paradoxical Air Embolism - gas crossing from the right atrium to the left atrium and entering the systemic circulation.

Patent Foramen Ovale (PFO) - Foramen Ovale is a flap-like opening between the right atrium and the left atrium. Generally begins closing at birth with complete closure by age 2. When it does not close, it is called a Patent Foramen Ovale. PFOs are believed to be present in 30-45% of adults.

Trans-Ischemic Attack (TIA) - A TIA is a temporary blockage of blood flow to the brain. TIAs are often labeled “mini-strokes” because they generally resolve in minutes to a few hours. Like most strokes,

Vascular system - also called the circulatory system, is made up of the vessels that carry blood and lymph through the body.

Ventricular Septal Defect (VSD) - a hole in the wall between the heart’s lower chambers.

For additional resources and more information, visit our website, www.clearlinemd.com or contact us at info@clearlinemd.com.
Air Embolism Sources
