



"VENOUS AIR EMBOLISM AND ANAESTHESIA."

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ABSTRACT

Vascular air embolism (VAE) is the entrainment of air or gas from operative field or other communications into the venous or arterial vasculature. High risk surgeries for VAE are surgeries in sitting position, posterior fossa neurosurgeries, obstetric surgeries and laproscopic surgeries. Risk factors for VAE are operative site 5 cm above the heart and creation of pressure gradient which will facilitate entry of air into the circulation. Large bolus of air can lead to right ventricular air lock and immediate fatality.

VAE affects various systems of the body like cardiovascular, pulmonary and central nervous system. The most sensitive device which will detect smallest amount of air in the circulation is transesophageal echocardiography. Treatment of VAE is to prevent further entrainment of air, reduce the volume of air entrained and haemodynamic support. Mortality of VAE is very high and ranges from 48 to 80%. VAE can be prevented significantly by proper positioning during surgery, optimal hydration, avoiding use of nitrous oxide and care during insertion or removal of central venous catheters.

KEYWORDS : Vascular air embolism, Posterior Fossa Neurosurgeries, Transesophageal echocardiography.

INTRODUCTION

VAE is the entrainment of air (or exogenously delivered gas) from open operative field or communication with environment into the venous or arterial vasculature, producing systemic effects⁽¹⁾. VAE is the most common embolic event to occur during the intra-operative period. In neurosurgical patients the incidence of VAE varies from 10 to 80%⁽²⁾.

VAE is a life threatening condition. Most of the episodes of VAE are preventable if precautions are taken. Early detection and treatment is important. VAE can be venous or arterial and both conditions can be differentiated by mechanism of air entry as well as site of embolization. The venous or pulmonary air embolism is air in systemic venous circulation reaching the right ventricle while arterial air embolism occurs due to entry of air in to the arterial circulation and leading to circulatory deficiency.

Etiology

The primary etiology of VAE is surgical procedure where the operative site is above the level of heart, such as sitting neurosurgical procedure, posterior fossa surgery, obstetric procedure and orthopedic surgeries^(3, 4, 5). Another reason is iatrogenic creation of pressure gradient which facilitate air entry into the circulation such as during insertion of central venous catheter⁽⁶⁾.

Risk Factors

1. Operative site more than 5 cm above right atrium.
2. In Posterior Fossa surgery because of various large non-compressed venous channels in the surgical field.
3. Surgeries creating a pressure gradient⁽⁷⁾.
4. Barotrauma or Chest Trauma as it causes alveolar rupture into small veins and capillaries leading to direct air entry into the circulation⁽⁸⁾.

Clinical Features

1. Small amount of air will not cause any clinical manifestations as it gets absorbed from circulation.
2. Moderate amount of air causes pulmonary vascular injury which can lead to pulmonary hypertension and pulmonary edema⁽⁹⁾.
3. A large bolus of air will cause air to get locked in the right side of the heart which leads to flow obstruction in the right ventricular and eventually death⁽¹⁰⁾.
4. The fatal amount of air in human is reported to be either 200 and 300 ml bolus or 3-5 ml/kg⁽¹¹⁾.

In CVS the features are chest pain, brady or tachy arrhythmias and right sided heart failure.

ECG shows right ventricular strain pattern⁽¹²⁾.

The respiratory symptoms include dyspnoea, tachypnoea, hypoxaemia or even pulmonary edema. Reduced lung compliance, increased dead space and shunting leading to hypoxaemia and hypercarbia⁽¹³⁾.

In CNS we have cerebral hypo-perfusion and high chances of direct paradoxical cerebral embolism through patent foramen ovale.

Diagnosis

1. Unexplained hypotension or sudden decrease in end-tidal CO₂ level.
2. Shortness of breath during or immediately after insertion or removal of central venous catheters.
3. In caesarean section who suddenly develops hypotension and hypoxia after delivery.
4. The transesophageal echocardiography as it can detect 0.02 ml/kg of air or air bubbles as small as 5-10 microns⁽¹⁴⁾.
5. Precordial doppler ultrasound (most sensitive non-invasive monitoring) can detect as little as 0.05 ml/kg of air⁽¹⁵⁾.
6. End tidal nitrogen (ETN₂) as it can show the changes 90 seconds earlier than end-tidal carbon dioxide (ETCO₂) changes⁽¹⁶⁾.
7. End-tidal carbon dioxide (ETCO₂) is the most common and easily available monitoring, which will reveal sudden decrease in level in event of VAE⁽¹⁷⁾.
8. Transcranial Doppler and ECG changes.
9. Pulmonary artery catheter will show rise in pulmonary artery pressure.
10. Computed Tomography (CT) chest will show air in central venous system, ventricles, pulmonary artery or pneumothorax.
11. CT brain may show intravascular air with or without infarction.

Treatment**Goals:**

To preventing further air entry, reduction in volume of air entrained, and haemodynamic support.

METHODS:

1. Immediately covering the surgical field with saline soaked

- dressing.
- Jugular venous compression using central line placement in sitting position surgeries.
 - Administration of 100% oxygen or Hyperbaric Oxygen Therapy.
 - Maintaining the systemic arterial pressure with optimal fluids and inotropic support.
 - Air lock in right side of heart may be relieved by partial left lateral decubitus position.
 - Trendelenburg's position.
 - Aspiration of air from right atrium using Bunegin-Albin multiorifice catheter.
 - In case of cardiac arrest rapid cardiopulmonary resuscitation with chest compressions can save lives.
 - Anticoagulation therapy with heparin in patients with air embolism decreases the severity of the disease.

Methods of Prevention

- Park Bench position for neurosurgeries.
- During caesarean section, left tilt and reverse trendelenburg position⁽¹⁵⁾.
- Avoiding the use of nitrous oxide⁽¹⁶⁾.
- Optimum Positive end expiratory pressure (PEEP) but is controversial⁽¹⁷⁾.

CONCLUSION

Vascular air embolism (VAE) is a preventable medical emergency. Apart from sitting position neurosurgical procedures, VAE is common in obstetric and laproscopic surgeries. Small amount of air in the circulation get absorbed but large bolus of air can cause air lock in the heart causing sudden death. Clinical manifestation of VAE is mainly due to the involvement of respiratory, cardiovascular, and central nervous system.

Precordial doppler ultrasound is the most sensitive method in detection of air embolism. Anticipation and suspicion in high risk patients along with knowledge of VAE are the corner stone for diagnosis and management of such patients.

The goal of treatment of VAE is to prevent further air entry in the circulation, reduction in volume of air entrained and haemodynamic support. Aspiration of air from heart will immediately improves the haemodynamic parameters.

Hence, to prevent occurrence of VAE the proper positioning during surgery, optimal hydration, and meticulous precautions during insertion and removal of central venous catheter is of vital importance.

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