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Venous Air Embolism during Hysteroscopy: A Potentially Catastrophic Complication

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ABSTRACT

Hysteroscopy as a minimally invasive procedure has gained immense popularity over the last few decades and has become the procedure of choice for many diagnostic and operative procedures. With the increase in the number of procedures being performed, the associated complications have started becoming apparent. Complications include perforations, fluid overload, infections and air/ gas embolism of which fluid overload and embolism are potentially hazardous. During hysteroscopy, large uterine veins may become exposed and serve as an entry point for gas or air. The present article discusses the pathophysiology, symptomatology, signs, management and preventive strategies with respect to air embolism in hysteroscopy.

Keywords: Hysteroscopy, embolism.

INTRODUCTION

Hysteroscopy is a minimally invasive procedure which involves gaining access to the uterine cavity by introducing a scope through the cervix. It allows direct visualization of the uterine cavity aiding in the diagnosis of intrauterine pathologies as well as management by simultaneous surgical interventions. Diagnostic and therapeutic procedures in myriad of clinical settings like infertility, endometrial polypectomy, abnormal uterine bleeding, asherman's syndrome, submucosal myomas, embedded intrauterine contraceptive devices etc can be performed. It also allows access to utero-tubal junction and henceforth the fallopian tube. It thus allows for hysteroscopic tubal occlusion procedures and fallopscopy. It has become a major tool in gynaecologist's kit for various diagnostic and operative purposes.

Medline, Pubmed, Google Scholar and Scopus electronic databases were searched for systematic reviews, case reports and case series. The databases were searched using MeSH terms 'air embolism in hysteroscopy', 'complications of hysteroscopy', 'air/gas embolism', 'venous air embolism' and 'management of venous air embolism'.

Despite being a minimally invasive procedure and being considered seemingly harmless, hysteroscopy has its own unique set of complications. The overall complication rate for hysteroscopy is 2% with serious complications occurring in less than 1% of cases.¹

Various complications reported are uterine perforation (0.76% in operative, 0.13% in diagnostic), fluid overload (0.2% in operative and nil in diagnostic)² and infectious complications (0.85% in operative hysteroscopy, no data for diagnostic).^{3,4} Gas embolism is a hazardous complication of hysteroscopy and an incidence of 10% to 50% has been reported in a number of fatal or near-fatal cases.^{5,6} Fatal and nonfatal venous air embolism (VAE) is described in several neurosurgical, laparoscopic, orthopaedic, gynecological, and hysteroscopic surgeries as well as in association with central venous access devices and intraosseous cannulas. Operative procedures are more often associated with complications than the diagnostic ones.² The most precarious hysteroscopic procedures associated with VAE are intrauterine adhesiolysis (4.48%), endometrial resection (0.81%) and myomectomy (0.75%) with a relatively lower complication rate for polypectomy (0.38%).² Interestingly when a small cohort (N=23) of women undergoing hysteroscopy was assessed by transthoracic echocardiography for the evidence of air bubbles, 100 % patients had embolism in right heart and 85% had continuous flow of bubbles.⁷

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MECHANISM OF AIR EMBOLISM IN HYSTEROSCOPY

Embolism is a blockage of a blood vessel by an embolus; which can be blood clot, air, amniotic fluid etc. It may be clinical or subclinical and is associated with a number of manifestations. Inadvertent incision of non-collapsed veins with sub-atmospheric pressure during the surgical procedure serves to create a pressure gradient between the point of entry of the gas and right side of the heart. This gradient is exaggerated by high pressure of the distension media. Thus, in this way gas or air enters into the systemic circulation. The steep trendelenburg position which is often used during combined laparo-hysteroscopic procedures exacerbates the embolism. This gas is then transported via the circulation into the lungs through the pulmonary arteries leading to cardiac arrhythmias, gas exchange disturbances and pulmonary hypertension. These pressure changes can open previously closed foramen ovale and lead to paradoxical embolism.⁸ Owing to filtration function of pulmonary circulation, the smaller gas emboli diffuse into the alveoli and are exhaled. The larger air emboli can cause an air lock in the right atrium and ventricle which can lead to phenomenon of outflow obstruction leading to decreased pulmonary venous return and finally resulting in decreased cardiac output. The critical amount of air required for significant clinical effects is more than 3 ml/kg.^{9,10} Closer is the site of entrainment to the heart, lower is the lethal volume of the gas. The clinical presentation may have a wide range of suggestive features like hypoxia, tachypnea, hemodynamic instability and pulmonary hypertension. This may eventually result in electromechanical dissociation, asystole or cor-pulmonale. Another pathophysiological pathway includes activation of inflammatory pathway in the lungs leading to non-cardiogenic pulmonary edema. Occlusion of cerebral artery and coronary arteries may occur because of paradoxical embolism and may lead to associated symptoms.

Another mechanism could be the entrapment of air/gas in the venous circulation when larger uterine vessels are injured during hysteroscopy. This gas can travel directly to the right side of heart through iliac vessels and inferior vena cava. Therefore, in surgeries involving larger surface area like transcervical resection of endometrium or hysteroscopic myomectomy, larger areas of these vessels are exposed, leading to larger

emboli and thus the complications. These embolizing gases may emanate as a result of electrocoagulation (hydrogen, carbon monoxide, and CO₂) or from the room air (nitrogen and oxygen).^{11,12}

Air might enter into the circulation during a hysteroscopic procedure while dilation and curettage, by air bubbles in the distension medium or hysteromat, leaving the cervix and vagina open to air when vascular injury is present or by repeated reintroduction of instruments through the cervix causing a piston like action leading to air entry inside the uterus with each reinsertion. Use of non-collapsible bottles and not using mechanized pumps for irrigating fluids, keeping the irrigating fluids at a higher position to attain higher intrauterine pressure and using external pressure infusers or laparoscopic insufflators for hysteroscopic purposes further worsens the situation.

SIGNIFICANCE OF COMPOSITION OF EMBOLISING GAS

Different gases have different chemical properties and behave in their own characteristic way after getting embolized into the circulation. A gas with higher solubility has a lesser incidence of bubble formation and its further consequences and vice versa. Ambient nitrogen has a greater bubble formation capability in comparison to carbon dioxide or oxygen. Reason attributed to this phenomenon is because the former has far less solubility in the blood in comparison to latter. Carbon dioxide is the most soluble gas amongst carbon oxide, nitrogen, air and nitrous oxide. Lethal dose of carbon dioxide is five times more than that of air making air embolism far more hazardous.¹³

SYMPTOMS AND SIGNS

Patients undergoing the surgery under spinal or epidural anesthesia report symptoms like chest pain or dyspnea (20-50%) and 30-72% patients have a fall in saturation.¹⁴⁻¹⁵ There may be evidence of bronchospasm and pulmonary edema. A mill-wheel murmur (characteristic splashing auscultatory sound due to the presence of gas in the cardiac chambers) can be heard on auscultation. On doing a precordial doppler ultrasound, air/gas can be detected in the heart. When in general anesthesia, a sudden fall in end tidal carbon dioxide (et CO₂) is observed on the monitor. There is a fall in oxygen saturation. The monitor can

also record the electrocardiogram changes like rhythm disturbances, premature ventricular contractions, heart blocks, S-T changes. Air can be detected in the heart by transesophageal echocardiography or precordial Doppler.

Summarizing the above, the following should serve as warning signs:

- Sudden decrease in et CO_2 , especially when accompanied by a decrease in blood pressure
- Decrease in oxygen saturation as measured by pulse oximetry
- Cardiovascular collapse
- Sustained hypotension not explained by hypovolemia alone
- Electrocardiography changes

MONITORING OF PATIENTS DURING THE SURGERY

When a patient is undergoing an office hysteroscopy, pulse oximetry should be done for monitoring purposes. When in regional anesthesia, pulse oximetry, electrocardiography and blood pressure monitoring should be done. Standard monitoring of the patient during general anesthesia consists of pulse oximetry, 3-lead electrocardiography, blood pressure monitoring, et CO_2 monitoring, and ventilatory monitoring. Et CO_2 monitoring has utmost importance in picking up embolism and a change of even 2 mm Hg et CO_2 may be attributed to embolism. Many physiologic changes such as hypovolemia, ventilator changes, and artefacts may exhibit similar fall in et CO_2 making it a very nonspecific sign. A decrease in oxygen saturation is relatively late and nonspecific sign. Electrocardiographic changes are considered one of the earlier signs in large embolism and even small amounts of air in right coronary artery results in ST segment changes. Transesophageal echocardiography is the most sensitive modality in detecting emboli. However it is expensive, requires expertise, requires the constant attention and is invasive. Precordial doppler ultrasound is another sensitive and valuable noninvasive monitoring method but its use is limited during electrocoagulation.

MANAGEMENT OF AIR/GAS EMBOLI

It is imperative that the complication is rapidly identified, and further gas entrapment is prevented by closing the point of air entry. The woman should

be immediately placed in reverse trendelenberg position thereby placing the heart above the point of air entrainment and preventing further air entry.^[8,16] Durant maneuver can be useful in these situations. This involves placing the patient on the left side while using Trendelenburg position. It helps to prevent air from occluding the outflow tract by placing the right ventricle more superior.¹⁷ 100% oxygen should be administered immediately to the patient to help oxygenation and additionally dissolve any other gases like nitrogen. Air retrieval using a central venous catheter or direct needle puncture of the right heart are advocated to stabilize circulation. Cardiopulmonary resuscitation and inotropic support should be done as per situation. Nitrous oxide increases the volume of entrained air and should not be used as an anaesthetic agent in cases with a high risk of air embolism.¹⁸ Cardiac massage can disrupt the air lock and force gas from the larger pulmonary arteries to smaller vessels but may increase the pulmonary hypertension.¹⁹ Hyperbaric oxygen therapy may be used in patients with severe central nervous system or cardiac manifestations but availability and necessity to start therapy immediately in these patients limits its use.^{20,21}

PREVENTIVE MEASURES

The operation theatre staff should be well trained. There should be high level of awareness regarding the use and upkeep of the instruments as well as the operative procedures being performed along with the anticipated complications. There should be a set protocol for managing emergencies and the theatre team should be well rehearsed with these emergency management protocols. Importance of safe use and maintenance of fluid management systems should be emphasized. Utmost care should be taken so that air entry into fluid lines and hysteroscopic instruments is avoided.

Pumps should be turned off during bag changes, and fluid balance should be monitored closely. A Y-connector should be used on the fluid inflow line to reduce air entrainment during bag changes. All tubings and hysteroscopic instruments should be purged of air. Mechanized pumps should be used for irrigating fluid. The height of fluid bottles should be restricted to less than one meter above the patient. Use of external pressure infusers should be avoided. Pressure inside the uterine cavity to be kept <100 mm Hg during

hysteroscopy. Intra-abdominal pressure should be less than 10-12 mm Hg. Cervical priming with agents like misoprostol or laminaria tent or intracervical injection of vasopressin should be considered in cases requiring difficult dilatations because majority of the complications of hysteroscopic surgery are related to cervical dilatation or uterine entry insertion difficulties.^{22,23} In case a dilatation and curettage needs to be performed in the same sitting, it should be done after the hysteroscopy. The exposure of the cervix to air should be minimum and it should be kept closed at all times; a tenaculum can be used to this effect. Repeated reintroductions of instruments into the uterine cavity, causing a piston like action should be avoided. A continuous irrigation system should be used so that the distension medium keeps on getting changed and the debris and air bubbles are flushed. In case of any injury to the uterus, the anesthetist should be informed and extra vigilance should be kept.

In an event of suspected air/gas embolism, the surgery should be terminated, uterus deflated, all hysteroscopic instruments removed, and the cervix covered with a wet mop.

As steep trendelenberg positions are associated with increased risk of embolism, these positions should be avoided as far as possible and if permissible from operative side, then the patient may even be kept in flat or reverse trendelenberg position.⁸ The use of nitrous oxide as an anesthetic agent may enlarge the size of air bubbles and, thus, should be avoided whenever possible in operative hysteroscopy.²⁴

High risk patients (e.g. septum defects) undergoing operative hysteroscopy should have extensive intraoperative monitoring like transesophageal echocardiography or precordial doppler ultrasound over and above the standard monitoring. Transesophageal echocardiography has the maximum sensitivity and can detect right to left shunting and even 0.5 ml of air bubbles. Transesophageal echocardiography probes, central venous catheters, arterial cannulas, resuscitation equipment and drugs should be kept ready and within reach in all cases.

Office hysteroscopy with minimal monitoring should be limited to diagnostic procedures. Operative procedures especially those requiring dilatation of the cervix should be done in well-equipped operation theatre under anesthesia and monitoring. Moreover, in potentially high risk patients like those with septal

defects, office hysteroscopy should be discouraged even for diagnostic purpose.

CONCLUSION

Air embolism is an infrequent but catastrophic complication associated with hysteroscopy, especially the operative hysteroscopy. Vigorous cervical dilatations and various operative procedures can open venous sinuses that serve as channels for air entrainment into the venous system, which enters the uterus along with the distension media. Quick detection and active resuscitative measures by the anesthetist along with retrieval of the embolus through central catheter can be life saving. Preventive measures include prevention of entry of air bubbles in the distension media, avoiding steep trendelenberg positions, cervical priming in cases of difficult cervical dilation, intensive monitoring during the surgery and preparedness for dealing with emergent conditions.

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