Venous gas embolism in operative hysteroscopy: A devastating complication in a relatively simple surgery

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Abstract
Venous air embolism can be a catastrophic iatrogenic complication during operative hysteroscopy and makes this simple surgical procedure very risky, especially with the lack of knowledge about its prevention, presentation, and immediate management. Three out of 13 hysteroscopic myoma resections at our center had venous gas embolism (VGE). The prevention, diagnosis, and management of VGE are described in this report of three cases.

Keywords: Anesthesia, operative hysteroscopy, venous gas embolism

Introduction
Hysteroscopy is a commonly performed procedure for the diagnostic and therapeutic interventions in infertility evaluation. Although operative hysteroscopy is a low-risk procedure and usually done in healthy patients, the association of venous air/gas embolism (VAE/VGE) has been a matter of serious concern. Embolism during operative hysteroscopy can be either air (atmospheric air) or gas (ingress of insufflating gas such as carbon dioxide or smoke generated during electrothermal procedure). Multiple fatal and nonfatal cases of embolism have been reported in the past with incidence of 10–50%.¹,² We encountered VGE with an incidence of 27 in 13 cases of operative hysteroscopies during the last three years.

Case Reports
Case 1
A 35-year-old female with primary infertility was diagnosed to have uterine fibroid distorting the uterine cavity. Diagnostic laparoscopy to study the pelvic anatomy and hysteroscopic fibroid resection was planned. Standardized general anesthetic technique was used, and patient’s airway was secured with an endotracheal tube. After an uneventful diagnostic laparoscopy, hysteroscopic resection of uterine fibroid was initiated. Uterus was distended with glycine under pressure (no documented pressure). Ten minutes into the procedure, patient’s heart rate (HR) suddenly dropped to 40 beats/min from 96 beats/min and the blood pressure (BP) fell to 80/50 mmHg from 130/90 mmHg. This drop was accompanied with fall in end-tidal carbon dioxide (EtCO₂) to 14 mmHg from 36 mmHg. Surgery was stopped immediately. On auscultation, bilateral fine crepitation was audible and hemoglobin saturation (SpO₂) displayed the value of 85% with 50% oxygen and 50% nitrous oxide. Injection atropine 0.6 mg was immediately administered, and 100% oxygen was also administered. Hypotension was treated with rapid intravenous saline infusion and 6 mg boluses of intravenous mephenetermine. HR, BP, and EtCO₂ responded to these measures. When hemodynamics and EtCO₂ were stable for 15 min, surgeons were requested to assess the amount of pervaginal bleeding which was not significant. The patient was then shifted to the Intensive Care Unit for cardiac

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evaluation. Cardiac evaluation was found to be normal, and a retrospective diagnosis of VAE was made as the cause of crisis during surgery.

**Case 2**
A 34-year-old patient was planned to undergo diagnostic laparoscopy and hysteroscopy for infertility. An uneventful diagnostic laparoscopy was performed under standard general anesthetic technique, and patient’s airway was secured with an endotracheal tube. Nitrous oxide was omitted and anesthesia was maintained with 100% oxygen with isoflurane 1% end-tidal concentration. The patient was placed in reverse Trendelenburg’s position, and uterus was distended with glycine at a pressure of 50 mmHg using Univac Duo (Biomedical Engineering). Distension pressure was decided by the minimum pressure required for adequate surgical vision. Around 5 min after starting fibroid resection, there was sudden increase in the HR and was followed by a continuous decrease in EtCO$_2$, SpO$_2$, and BP. Chest auscultation revealed a millwheel murmur. Surgeon was immediately notified and asked to drain the uterus and pack the vagina with wet gauze. The patient was then positioned in the left tilt and head down position (Durant’s maneuver). By this time, electrocardiogram (ECG) demonstrated sinus tachycardia (150 beats/min). Injection metoprolol 1 mg and injection mephentermine 6 mg were given intravenously. HR decreased to 100 beats/min, and BP improved to 104/60 mmHg. In the next few minutes, EtCO$_2$ started increasing. Transthoracic two-dimensional (2D) echocardiography (ECHO) was performed in the operation theater, and air bubbles were visualized in the right atrium which spontaneously cleared in the next few minutes.

**Case 3**
A 38-year-old patient with submucous fibroid was posted for hysteroscopic resection. General anesthesia with endotracheal intubation was performed and surgical procedure was initiated. After around 10 min of resection time, sudden drop in EtCO$_2$ and SpO$_2$ was noticed. Immediate cardiac auscultation revealed millwheel murmur. The patient was given left lateral tilt in head down position. Surgery was stopped and vagina was packed with wet gauze piece. There was no drop in BP and no significant change in HR. Transthoracic 2D ECHO confirmed the presence of multiple bubbles in the right atrium and ventricle [Figure 1]. Intracardiac air volume was constantly monitored, and the patient was kept with left lateral tilt in head down position. Till 15 min, intracardiac air could be visualized [Figure 2] and EtCO$_2$ remained around 15 mmHg. Slowly, the EtCO$_2$ improved as the air disappeared from the cardiac chamber as visualized by 2D ECHO. Surgery was abandoned and patient after awakening was shifted to the recovery room with no neurologic deficit.

**Discussion**
Mortality can be as high as 46% with VAE. In one case series of 13 cases, six patients had a fatal outcome.[3] However, a vigilant anesthesiologist’s timely intervention, termination of the surgical procedure at the right time, and thus terminating the continued entrainment of air/smoke/gas bubbles can help decrease morbidity and mortality. Case 1 was retrospectively diagnosed as VGE by exclusion, and the diagnosis was supported by fall in EtCO$_2$, BP and SpO$_2$. After the first case, departmental meeting was held and following the discussions; protocols were introduced to avoid air embolism as advised by Corson et al.[4] Most notably, the following changes were introduced in the management of these cases.

1. All cases will be done under general anesthesia with endotracheal intubation and EtCO$_2$ monitoring
2. Cervix will not be exposed to air after dilation, and either a dilator or wet gauze will be used to pack vagina between dilations
3. Trendelenburg’s position should not be given at any time
4. Irrigation system should be checked to be free of air
5. Uterine distension pressures were reduced to minimum required for adequate vision (50–100 mmHg) in most of the cases
6. Weighted speculum will not be used in any case
7. Nitrous oxide will not be used.

Despite the above protocol, Case 2 was encountered. The patient was immediately given Durant’s maneuver, and 2D ECHO was performed to confirm the diagnosis. It was doubtful that embolism was because of atmospheric air and the only thing which could be implicated was the smoke generated during electrothermal reaction. Even though this patient recovered faster than the first patient, there could be certain factors contributing to the VGE.
Maximum uterine distension pressure of 200 mmHg and maximum CO₂ flow rate of 100 ml/min were suggested by Siegler and Valle. Female genital tracts are vulnerable for the entainment of air into venous plexus. VAE has been reported during abortions, hysteroscopy, cesarean sections, and even orogenital sex during pregnancy. Leibowitz et al. had demonstrated the presence of air bubbles in the right atrium using transesophageal ECHO (TEE) in all the 23 subjects with 85% of patients showing continuous flow of bubbles during the procedure. It has been suggested that the liver might be acting as a natural bubble trap bringing down the incidence of clinically significant VAE even with very high incidence of clinically insignificant air embolism document on TEE. Patricia et al. recommended continuous precordial Doppler, EtCO₂ monitoring along with avoidance of N₂O during anesthesia and air in the irrigation fluid. Other factors which have been implicated in increasing the chances of VGE are repeated instrumentation that can cause “piston-like” transmission of air into the uterus, steep Trendelenburg’s position (can cause negative pressure in the pelvic veins which subserve ingress of air into the systemic circulation), and inadequate purging of air from the irrigation system.

Presenting features of VAE can be fall in EtCO₂, desaturation, hypotension, “mill wheel” murmur, bradycardia, bronchospasm, respiratory and cardiac arrest. We encountered fall in EtCO₂ and desaturation in all of our cases, “mill wheel” murmur in the second and the third case, bronchospasm and bradycardia in one case, and tachycardia in two of the cases. According to Corson et al., Cardiac Doppler is the most sensitive method for detection of VGE, followed by fall in the EtCO₂, increase in pulmonary arterial pressure and central venous pressure, fall in BP, ECG changes, and fall in PaO₂ in the decreasing order of sensitivity.

Most of the earlier reports and publications of VAE during operative hysteroscopy mentioned about the air embolism due to cervical trauma caused by cervical dilation and measures were suggested to prevent it. Cervical priming using misoprostol or Laminaria tents have been advised to decrease the chances of cervical trauma. Two of the three cases we described certainly did not have air embolism and the only possibility was of embolism of smoke, developed due to the heat generated during electrothermal coagulation and cutting off the myoma as suggested by Imasogie et al.

One notable observation in the last case was a decrease in the irrigation fluid outflow, which was mentioned to the surgeon. Thus, it could be contemplated that increased absorption of the irrigation fluid could have carried the smoke bubbles to the intravascular compartment. Dyrbø et al. reported more extensive embolism with intravasation of distension fluid exceeding < 1 L. They also observed equal occurrence of VGE irrespective of the type of diathermy. The American Association of Gynecologic Laparoscopists advocates the use of automated fluid pump and monitoring system.

As with any potential complication of a procedure, treatment of air/gas embolism starts with prevention and early detection. Once identified the following steps should be taken:

1. Surgeon should be notified and surgery should be immediately stopped
2. Irrigation fluid pressure should be released
3. Patient positioned in Durant’s maneuver to prevent air lock of the right ventricular outflow tract
4. A hundred percent oxygen should be administered even if there is no desaturation
5. If hypovolemia is suspected, infuse intravenous fluids to increase central venous pressure
6. Inotropes and vasopressors should be used as required to maintain vital organ perfusion
7. Keep the central venous catheterization set ready to retrieve the air from the right ventricle outflow in case of cardiac arrest or persistent hemodynamic instability.

Intropic support and cardiopulmonary resuscitation should be instituted as necessary. Hyperbaric oxygen has been advised but its role in the treatment is debatable and it is not widely available.

**Conclusion**

VAE is a frequent complication during operative hysteroscopy. As with any other complication, prevention is essential and needs input from all the members of the surgical team. Strict vigilance along with adequate monitoring is of paramount importance in the early diagnosis and initiation of management.
If facilities are available, use of advanced monitoring such as transthoracic 2D ECHO can help in confirming the diagnosis and in management of the cases. Prevention and treatment of VGE have to be a team effort involving active participation from surgeon, anesthesiologist, nurses, and operating room technicians.

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Conflicts of interest
There are no conflicts of interest.

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