Commentary

Commentary: Venous air embolism during hysteroscopy: A stitch in time saves nine!

Minimally invasive surgeries are gaining increasing popularity in all surgical fields and have become the method of choice for diagnostic and therapeutic interventions of intrauterine pathology. Advantages consist of short operating time, rapid postoperative recovery, and low morbidity. Nonetheless, female genital tract is particularly vulnerable for air/gas entrainment into its venous plexus. Venous air embolism (VAE) is a rare but potentially lethal/disastrous complication of operative hysteroscopy and was first reported in 1985.[1] The symptoms of VAE range from minor and having no clinical significance to complete cardiovascular collapse during surgery. Cases of VAE may suffer from a very high mortality reaching up to 46%.[2] Incidence of hysteroscopy-related fatal and nonfatal cases of VAE has been variably reported as 10–50% depending on the detection method used.[3,4] Using transesophageal echocardiography (TEE) in patients undergoing hysteroscopy, Leibowitz *et al.* could demonstrate the presence of air bubbles in the right heart of 100% of the subjects.[5] It has been proposed that the liver might be acting as a natural bubble filter, making most such events of VAE clinically insignificant. Early detection and intervention are crucial to avert the grave complication of this benign procedure and improve patient outcome, and hence, awareness of the syndrome complex is important.

Venous embolism during diagnostic/operative hysteroscopy can due either to the ingress of either air (atmospheric air) or other gases (insufflating gas such as carbon dioxide or electrosurgical vapors generated during electrothermal procedure). For gas embolism to occur, certain conditions have to be present, open venous channels in contact with gaseous medium, and an operating site above the level of the heart creating a pressure gradient. Opening of large uterine venous channels/false passages created during forceful cervical dilatation for the insertion of the hysteroscope or in cases of uterine trauma exposing circulation to ambient air and other gases along with negative intrathoracic pressure during spontaneous breathing have been proposed as important mechanisms.[1,2] Improper purging of lines or repeated reinsertion of hysteroscopic instruments are important factors.

The characteristic clinical features include fall in $EtCO_2$, desaturation, "mill wheel" murmur, bradycardia, tachycardia, bronchospasm, respiratory and cardiac arrest, etc.[2] Amount of intravasation of distension fluid has been found to correlate

with severity of embolism and VAE is more extensive in patients with intravasation exceeding a liter.[6] TEE is the most sensitive method for detection of VGE and even 0.5 mL of air bubbles can be detected. Patricia *et al.* recommended the use of continuous $EtCO_2$ monitoring, Doppler ultrasound, and avoidance of N_2O in anesthetic gas mixture and air in the irrigation fluid for preventing VAE.[7] Echocardiography is followed in sensitivity by a fall in the $EtCO_2$, increase in pulmonary arterial pressure and central venous pressure, fall in blood pressure, ECG changes, and fall in PaO_2.

The argument in favor of air embolism in the present case is as follow:

1. Patient positioning in lithotomy with Trendelenburg position
2. Difficult cervical dilatation
3. Sudden fall in $EtCO_2$, hypotension, bradycardia, desaturation, and ventricular tachycardia on ECG soon after the insertion of the scope
4. Wide gap between $PaCO_2$ and $EtCO_2$
5. Normal left ventricular function with dilatation of the right side of the heart and elevated pulmonary arterial pressures.

"Female transurethral resection of the prostate (TURP) syndrome" should be ruled out as a differential diagnosis by noticing any measurable deficit in the input/output of the fluid used for distension, and any signs suggestive of fluid overload.[1] TURP syndrome can occur when electrolyte-free hypotonic distension medium (sorbitol, glycine) are used during hysteroscopy leading to excessive fluid intravasation and hyponatremia. In the present case, isotonic normal saline was used as the distention media which is unlikely to cause hyponatremia and TURP syndrome though the difference in the volume of the returning fluid and the purged fluid has not been mentioned. However, like all distension fluids, it can lead to volume overload in the circulation, as mild pulmonary edema has been reported with infusion of 800 mL fluid under high pressure.[8] Uterine pressures should be monitored and kept below 50–100 mm Hg.[9] Authors of the present case have not reported the uterine distension pressure but fluid overload would not have such catastrophic presentation.

The patient was placed in lithotomy with the Trendelenburg position. Trendelenburg position should be avoided in these procedures to minimize VAE as it can cause negative pressure in the pelvic veins, which facilitates ingress of air into the systemic circulation.[1,2] The use of nitrous oxide should be avoided as it can increase the volume of entrained air and endotracheal intubation with positive pressure ventilation is preferred.[2,4,9] Whether nitrous oxide was used in this case or not is not clear. Hysteroscopy should be performed using mechanical pump with Y connectors and external pressure infusers should be avoided.[2,4] The American Association of Gynecologic Laparoscopists advocates the use of automated mechanical fluid pump and pressure monitoring system.[10] The hysteromat set should be free of air, irrigation system should have been purged, and all connections should be air tight.[10,11] A dedicated person should be checking the presence of air bubbles in the fluid infusion system and care should be taken to exclude air while changing the fluids. Repeated re-insertions of hysteroscope are also important in increasing the chances of VAE by causing "piston-like"-forced transmission of pressurized air into the uterus.[12] Cervical priming using misoprostol or Laminaria tents can be useful in such cases with a fixed cervix to reduce the trauma because of its dilatation.[2,4] Cervical trauma is the usual inciting factor for air embolism in such cases and when difficult cervical dilatation was noted, the patient should have been positioned in the reverse Trendelenburg position to raise the level of heart above the air entrainment site. The presence of air in the pulmonary circulation probably led to severe pulmonary hypertension and elevated pulmonary pressures led to the sequel of right heart failure and pulmonary edema from which the patient could not recover.

Rapid identification and prevention of further gas entrainment into the circulation is crucial to the ultimate patient survival. The surgeon should immediately stop further procedure and deflate the uterus and disconnect sources of fluid and gas. Occlusion of the air entrainment site by using the dilator or wet guazes to pack the vagina is prudent at the first suspicion of air embolism in such cases. A patient should immediately be placed in the reverse Trendelenburg position to raise the level of heart to be placed above the place of air entry, reducing further air entrainment.[13] In case of a symptomatic patient, durant position is an immediate and effective measure to unlock the right ventricular outflow tract of air.[14] Air retrieval using a central venous catheter, or direct needle puncture of the right heart in the case of cardiac arrest, is one of the measures advocated to improve patient's condition. Resuscitative measures in the form of inotropic support and cardiopulmonary resuscitation as necessary should be employed. The suggested surgical and anesthetic measures to prevent or minimize VAE have been summarized in Tables 1 and 2, respectively.[2,4,6,9-15]

Conclusion

Venous air embolism is a preventable complication and every institute should devise protocols for operation theatre

Table 1: Perioperative surgical safety measures in patients undergoing hysteroscopy

Surgical safety measures
After cervical dilation, the cervix should be kept occluded at all times using a dilator or wet gauze.
Repeated insertions and removals of the hysteroscope should be avoided.
Even trivial uterine injury should be informed to anesthetist so that extra vigilance can be kept.
Weighted speculum should be avoided.
Cervical priming (e.g., with misoprostol or Laminaria tents) should be considered especially in nonparous patients or those who had prior cervical surgery.
Intracervical injection of dilute vasopressin can help in reducing VAE risk.
Dilatation and curettage should be performed after hysteroscopy.
If VAE is suspected, surgery should immediately be stopped, uterus deflated, and the cervical os occluded with wet gauzes.
Education and training of the surgical staff to raise awareness of the risks and preventive measures.

VAE: venous air embolism

Table 2: Safety measures during anesthesia for hysteroscopic procedures

Anesthesia safety measures
The patient should be placed in the supine/reverse Trendelenburg position.
Height of fluid bottles should be restricted to<1 m above the patient and external pressure infuser avoided.
Automated pumps should preferably be used for irrigating fluid and the hysteromat set and all tubings should be purged free of air bubbles.
A continuous outflow system should be used so that the distension medium is restored actively and bubbles and debris are flushed away.
An isotonic solution (0.9% NaCl) should be used as distension medium.
When infusion fluid deficit is >1000 mL with sorbitol or >1500 mL with saline, need of early termination of the procedure should be discussed with the surgeon.
Intrauterine pressure monitoring system should be used and pressure limited to <100 mm Hg.
$EtCO_2$ monitoring is mandatory in all cases. Advanced hemodynamic monitoring (cardiac Doppler) should be used especially in patients at high risk (e.g., ASD/VSD) undergoing operative hysteroscopy.
Resuscitation equipment and drugs along with central venous catheters and arterial cannulas should be kept ready to tackle emergency.
Patient should be kept optimally hydrated.
Positive pressure ventilation should be used while nitrous oxide (N_2O) avoided.

personnel, surgeons and anesthesiologists managing patients undergoing minimally invasive procedures. Immediate termination of the surgical procedure and a vigilant anesthesiologist's timely intervention is crucial in reducing the morbidity and mortality. Educating, raising risk awareness, and training the surgical staff and regular drills should be conducted to effectively manage emergencies.

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