Information sent to the USP will be forwarded to the appropriate regulating group and the manufacturer or vendor of the cylinder in question.

Compressed gas cylinders are potential hazards to patients and hospital personnel. In our survey, 120 (1.2 per cent) of 14,500 cylinders delivered to us had potentially hazardous irregularities. The hazards of medical gas delivery systems are not the result of a lack of regulations, but are the result of lack of compliance with existing regulations by gas suppliers and hospitals. All personnel involved with supplying and administering medical gases should be aware of the existing regulations to minimize accidental harm. Occupational Safety and Health Act (OSHA) standards require that each hospital determine that compressed gas cylinders used in that institution are safe (Section 1910. 166).[1] Experience in cylinder inspection is therefore important. OSHA recommends that users lacking experience in cylinder inspection should return any doubtful cylinders that do not have: 1) a label or tag indicating gas content, 2) the proper valve outlet, or 3) the proper color on the tank for the gas contained. Additionally, all problems with medical gas delivery systems should be reported, so that problems can be analyzed and regulations updated if necessary.

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Gas Embolism during Laparoscopy

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Surgeons and anesthesiologists involved with laparoscopic procedures are aware of the potentially dangerous complication of gas embolism, although the exact incidence is unknown. Bruhl reviewed 63,845 laparoscopies for diagnostic procedures other than tubal sterilization and found only one case of gas embolism among 1,594 serious complications.[1] Since laparoscopy is performed frequently all over the world for tubal sterilization and various diagnostic procedures, we decided to monitor 100 patients with Doppler ultrasonic instrument.

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Method

All patients undergoing laparoscopic procedures irrespective of age, color or prior disease, were included in the study.

The protocol included:

1) EKG monitoring
2) Placement of Doppler transducer over the right heart, secured with a circumferential strap
3) Administration of 3 mg *d*-tubocurarine or 20 mg gallamine triiodine, iv, to prevent fasciculation
4) Preoxygenation for at least 3–5 minutes
5) Rapid induction of anesthesia with 250–400 mg thiamylal followed by 100 mg succinylcholine for endotracheal intubation; when ventilation was necessary prior to intubation, a stomach tube was passed following successful intubation
6) Ventilation with nitrous oxide, 3l/min, and oxygen 2l/min
7) Agent of choice: Innovar, fentanyl, enflurane, or halothane
8) Insertion of esophageal stethoscope to monitor heart sounds
9) Nitrous oxide pneumoperitoneum

Results

During the monitoring of 100 patients for laparoscopy, the incidence of gas embolism of greater than 0.1 ml was nil.

Discussion

During laparoscopy, pneumoperitoneum is created for good visualization.[2] The ideal pressure varies between 10 and 20 torr. Two to three liters of carbon dioxide (CO_2), or nitrous oxide (N_2O) are commonly utilized for this purpose.[3] In developing countries, where such gases are expensive and not easily available, room air is utilized.

With neurosurgical techniques,[4,5] air embolism is a common occurrence. Careful monitoring by an ultrasonic technique that utilizes the Doppler effect for instantaneous detection of minute amounts of gas (0.1 ml) demonstrates air in the heart before auscultatory, electrocardiographic, blood pressure or blood-gas alterations become apparent. During laparoscopy conditions differ from those in neurosurgical procedures. Any opening in a vein is surrounded by positive pressure, which tends to collapse the vein. There is no incision through bone, which maintains an open vein. Chang *et al.*[4] reported a 25 per cent incidence in 400 neurosurgical cases, and Michenfelder and associates[6] reported the use of a transvenous catheter placed to extract air from the superior vena cava or right atrium. This venous line provided a rapid means of aspirating air from the heart, to reduce morbidity and mortality.

Gas embolism in patients with CO_2 pneumoperitoneum has been reported,[7] but not proven. Burman,[8] in a review of air embolism, points out that very little is known of its incidence, mortality rate, or the relative risks during pneumoperitoneum induced for tuberculosis. Recently, unexplained cardiovascular collapse has been responsible for several deaths in clinically healthy patients during laparoscopy.[9,10] If CO_2 pneumoperitoneum is associated with an incidence of CO_2 embolus, then the incidence with N_2O pneumoperitoneum should be higher, because the absorption of intravenous CO_2 is much faster than the absorption of N_2O.[11,12] Yet our monitoring of 100 cases failed to detect even 0.1 ml of gas. Our experience of ten years with 5,261 laparoscopic procedures and results of ultrasound monitoring of 100 patients support the fact that gas embolism has an extremely low incidence, and indicate that patients scheduled for laparoscopy do not require the sophisticated monitoring applicable to the neurosurgical case. An esophageal stethoscope[13] must be used to detect arrhythmias, but the subtle changes in the heart sounds—metallic, clicking, drum-like, slashing, and so forth—as the earliest physical sign produced by embolization of gas have not, to our knowledge, been reported to occur during laparoscopy.

When we began using N_2O for pneumoperitoneum, we used 100 per cent oxygen and halothane to reduce the size of N_2O bubbles accidentally introduced into the blood stream. Arrhythmias were less common with this technique than with halothane, N_2O and O_2 when CO_2 was utilized for pneumoperitoneum.[14] However, awareness occurred in one patient due to a malfunction in the anesthesia machine.[15] Our technique was changed to N_2O (2 l/min) and 0_2 (2 l/min) plus halothane or enflurane supplementation. Recorded Pa_{0_2} values were consistently above 120 torr.

During laparoscopy intra-abdominal pressure (IAP) rises above inferior vena caval (IVC) pressure.[16] IAP remains between 10 and 20 torr. Femoral-vein pressure (FVP) increases in parallel with IAP and maintains some flow through the IVC.[17] At this stage it is possible, in theory, to have a Venturi-like suck of gas entrained into a vein that has a ruptured wall. Since intravascular venous pressure rises above intra-abdominal pressure, bleeding from the damaged vein would seem more likely than gas entrainment. The negative results found by monitoring 100 patients with the Doppler ultrasound technique support this suggestion. It would seem logical to state that gas embolism could occur by direct iv injection, and hence could occur only at the time of insufflation.[7] The surgeon should always aspirate the Verres needle before insufflating gas to prevent direct introduction of gas into a blood vessel.

We conclude from our results and the large number of laparoscopies performed using an esophageal stethoscope that gas embolus is extremely rare during pneumoperitoneum for laparoscopy, regardless of the nature of the insufflating gas.

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