INTRODUCTION. Occult venous gas emboli (VGE) from insufflating gas (usually CO₂ or N₂O) have occurred during laparoscopy or hysteroscopy, occasionally leading to fatality. A practical means to detect early CO₂ or N₂O embolus has not been described. Of the common methods for VGE detection, abstrait heart sounds heard with an esophageal stethoscope are a late sign, precordial doppler echo changes are often too nonspecific to be routinely useful, and monitoring changes in pulmonary artery pressure is usually impractical during these procedures. An abrupt decrease in end-tidal CO₂ (ETCO₂) is a sensitive indicator of venous air embolus.1 As monitoring ETCO₂ and arterial oxygen saturation (SaO₂) in the operating room become routine, we may have a ready means for early detection of CO₂ and N₂O emboli. We investigated the effects of small CO₂ and N₂O emboli on ETCO₂ and SaO₂.

METHODS. Approval for this study was obtained from our animal care committee. Three full-grown oes weighing 45 to 60 kg and previously prepared with central venous and systemic arterial catheters were anesthetized with intravenous thialyl, paralyzed with pancuronium, and mechanically ventilated at a constant minute volume with either 100% O₂ or 67% N₂O in O₂ to produce a stable ETCO₂ of 35-40 mmHg. Anesthesia was maintained with an intravenous infusion of thialyl 8-10 mg/kg/h. ETCO₂ was continuously measured with a Puritan-Bennett Datex CO₂ monitor and recorder. SaO₂ was determined with a Radiometer OSM 2 Hemoximeter. Systemic arterial blood pressure was continuously measured with a Gould pressure transducer and Beckman recorder.

VGE, 1 ml/kg at 1 ml/sec were alternated between CO₂ and N₂O. SaO₂ was determined intermittently over a 10-minute period. VGE were given at least 30 minutes apart and only after measured variables had been stable for at least 20 minutes. After a total of 4 VGE, the ventilating gas was changed to either 100% O₂ or 67% N₂O. After an additional 30 minutes, when blood/salvar gas equilibration should have been completed, the sequence of gas injections was repeated. Time to maximal change in ETCO₂ and SaO₂ was noted, as was the time to recovery to 67% of control. To test the relative sensitivity of our preparation to detect VGE, an intravenous air injection 1/3 the volume of CO₂ or N₂O was given at the same rate.

RESULTS. CO₂ emboli decreased ETCO₂ 11 ± 2% (Mean ± S.D.) during ventilation with 100% O₂ and 32 ± 6% when 67% N₂O was used (p<0.05). With N₂O emboli, ETCO₂ decreased 25 ± 6% and 37 ± 8%, respectively (p<0.05). With a volume of air 1/3 as large, ETCO₂ decreased 47 ± 10% and 65 ± 12%, respectively. There was no change in SaO₂ from VGE during 100% O₂ ventilation. With 67% N₂O, CO₂ emboli produced a 9 ± 4% decrease in SaO₂ vs a 12 ± 3% decrease with N₂O emboli (p<0.05) and a 64 ± 15% decrease with air.

In the case of ETCO₂ and SaO₂, peak within 1 minute of the VGE. N₂O and CO₂ emboli did not change the time to 67% recovery of ETCO₂, which was 2.1 ± 0.4 min for CO₂ and 3.1 ± 1.9 min for N₂O (p<0.05). When 100% O₂ was used for ventilation, there was no significant change in mean systemic arterial blood pressure (MAP). With air emboli in the presence of 67% N₂O, MAP increased an average of 22 ± 8%.

DISCUSSION. As exogenous CO₂ entering the lungs from a CO₂ embolus may have blunted an anticipated decrease in ETCO₂, we originally hypothesized that small CO₂ emboli might decrease SaO₂ and yet remain undetected by an ETCO₂ monitor, inferring that N₂O would be the safer insufflation gas as N₂O emboli would be easier to detect. Our results show, however, that both CO₂ and N₂O emboli decreased ETCO₂. With 100% O₂ ventilation, N₂O emboli produced more than twice the decrease in ETCO₂ produced by CO₂ emboli. Sixty-seven percent N₂O ventilation increased ETCO₂ changes from all VGE; the greatest percentage change occurred with CO₂ emboli, so that there was no longer a significant difference in the effects of N₂O and CO₂ emboli on change in ETCO₂. With 67% N₂O, SaO₂ monitoring is also a sensitive detector of small VGE, producing similar changes with N₂O and CO₂ emboli.

REFERENCE.