

# The incidence and haemodynamic significance of gas emboli during operative hysteroscopy: a prospective echocardiographic study

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Aims	Operative hysteroscopy is associated with complications including the development of gas embolism. The aim of this study was to utilize continuous echocardiographic imaging during operative hysteroscopy to assess the extent and the haemodynamic effects of gas embolism in these patients.
Methods and results	Women undergoing operative hysteroscopy under general anaesthesia without a history of cardiac disease were eli- gible. Transthoracic echocardiography (TTE) was performed continuously in all study participants with assessment of the extent and frequency of gas embolism, right ventricular function and pulmonary hypertension. Twenty-three women (mean age: $48.0 \pm 9.4$ years) participated in the study. All subjects had evidence of bubble embolism in the right atrium (RA) and 20 of 23 (85%) had evidence of continuous flow of bubbles. In the 17 patients with ade- quate assessment, estimated pulmonary artery systolic pressure was $19.1 \pm 3.7$ mmHg prior to the procedure and $23.3 \pm 3.4$ following the procedure, a statistically significant difference ( $P < 0.05$ ). There were no significant changes between the two groups in right ventricular end-diastolic area, end-systolic area, or fractional area change.
Conclusion	Our study demonstrates a high frequency of continuous gas embolism during hysteroscopy, which is associated with a small but statistically significant increase in pulmonary artery systolic pressure without affecting right ventricular function.
Keywords	Echocardiography • Gas embolism • Pulmonary hypertension

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## Background

Operative hysteroscopy is a minimally invasive surgical technique commonly used in treating intrauterine pathology. While generally considered safe, hysteroscopy is associated with complications including the development of gas embolism reported to be up to 0.8%.<sup>1-2</sup> Large uterine venous sinuses communicate with the general venous circulation and if opened during the procedure, gases may be aspirated into the venous circulation, the right heart, and the pulmonary circulation.<sup>3</sup> Although clinically evident gas embolism is considered unusual it is a life-threatening complication, particularly in patients with intravascular right to left shunts such as patent foramen ovale.<sup>4-5</sup> The clinical diagnosis of gas

embolism may be difficult, particularly in the anesthetized patient as the wide range of signs and symptoms may mimic other, more recognized cardiovascular conditions.<sup>6</sup>

A recent study using transthoracic echocardiography demonstrated a high incidence of gas embolization during hysteroscopy<sup>7</sup> and the incidence of subclinical gas embolization may be more common than previously suspected.<sup>8</sup> No report has systematically examined the extent of gas embolism during operative hysteroscopy or its haemodynamic effects on the pulmonary vasculature or the right ventricle. The objective of this study was to utilize continuous echocardiographic imaging during operative hysteroscopy to assess the extent and the haemodynamic effects of gas embolism in these patients.

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### **Methods**

Candidates for the study were women over the age of 18 undergoing advanced operative hysteroscopy under general anaesthesia without a previous history of structural cardiac disease. We included subjects undergoing hysteroscopic myomectomy or endometrial resection, relatively complicated procedures. The patients were premenopausal women suffering from menorrhagia or menometrorrhagia who were referred to our department by their primary gynecologist. Once referred, they were further evaluated by the gynaecologic staff and if hysteroscopy was indicated they were recruited for the study after signing informed consent. Only one patient refused participation. The study was approved by the institutional ethical review board and informed consent was obtained from all participants. All surgical procedures were performed by a single experienced surgeon (Y.H.) and included endometrial ablation or myomectomy. The hysteroscopic procedures were performed with a bipolar system resectoscope using normal saline as distension media. The procedures were performed under general anaesthesia with laryngeal mask and positive pressure ventilation with tidal volumes of 7-9 cc/kg. Positive end-expiratory pressure was constant at 4 mmHg in all patients. Standard monitoring including heart rhythm, non-invasive blood pressure, arterial blood saturation (SaO<sub>2</sub>), and capnography was performed in all patients. The position of the operating table was flat in all subjects and Trendelenburg position was not used.

Transthoracic echocardiography (Sonos 5500, Agilent Technologies) was performed continuously using an S3 probe and second harmonic imaging by a single experienced cardiologist (D.L.) in the apical fourchamber view from induction of anaesthesia until removal of the resectoscope. All studies were recorded on videotape for further analysis. The extent of gas embolism was graded on a five-point scale as previously described with 0 being absence of bubbles in the RA, 1 being non-continuous, individual bubbles, 2 non-continuous groups of bubbles, 3 continuous groups of bubbles filling less than half the right atrium and 4 continuous bubbles filling more than half of the right atrium<sup>7</sup> (*Figure 1*). The total amount of time during the procedure for each of the types of bubble flow was assessed for each subject.

Using continuous wave Doppler, the peak velocity gradient over the tricuspid valve was measured prior to and immediately following the procedure. The right ventricular pressure was estimated with the modified Bernoulli equation and added to the estimated right atrial

pressure to obtain pulmonary artery systolic pressure. Measurement of the end-diastolic and end-systolic areas of the right ventricle were also performed prior to and following the procedure and fractional area change was calculated as a marker of right ventricular function.

Statistical analysis was performed using the paired *t*-test for parametric intragroup comparisons and the Wilcoxon signed-ranks test for non-parametric intragroup comparisons. Categorical variables were analysed using the Fishers exact or  $\chi^2$  tests where appropriate. A *P*-value of  $\leq 0.05$  was considered statistically significant.

#### **Results**

Twenty-three women (mean age  $48.0 \pm 9.4$  years) were entered into the study of whom 6 underwent myomectomy and 17 endometrial ablation. Mean time of the procedure was 17.1  $\pm$  8.1 min. All subjects had evidence of gas embolism in the RA during the procedure and 20 of 23 (85%) had evidence of continuous flow of bubbles (grades 3 and 4) at some point. Evidence of gas embolism in the RA appeared at a mean of 2.8 + 2.6 min after the start of the procedure generally in conjunction with myometrial invasion. Once bubbles appeared, the flow was constant in many patients and the study group had grade 3 and 4 flow for a mean of 48 + 39% of total procedure time. Four patients (17%) had individual bubbles noted in the left side of the heart at the time of grade 4 embolism in the RA consistent with right to left shunting (Figure 2). Seven subjects (30%) had episodes of desaturation (defined as  $SaO_2$  saturation <95%) during the procedure that resolved spontaneously without the need for intervention. In three of these patients desaturation occurred during grade 4 bubble embolism, in three during grade 3 and in one during grade 2.

Of the 23 study subjects, 17 (74%) had adequate measurement of tricuspid valve gradients prior to and following the procedure. Estimated systolic pulmonary artery pressure was  $19.1 \pm 3.7$  mmHg prior to the procedure and  $23.3 \pm 3.4$  following the procedure, a statistically significant difference (P < 0.05). There were no significant changes in right ventricular end-diastolic area, end-systolic area or fractional area change (*Table 1*).



Figure I Example of grade 2 gas embolism during hysteroscopy.



**Figure 2** Example of isolated bubbles in the left ventricle during grade 4 embolism.

## Table IAssessment of right ventricular function inthe study group

		Pre-procedure	Post-procedure	P-value
End-diast (cm <sup>2</sup> )	olic area	18.5 <u>+</u> 3.4	18.6 ± 2.9	NS
End-systc (cm <sup>2</sup> )	olic area	10.2 ± 2.5	10.1 ± 4.6	NS
Fractiona change	l area e (%)	41 ± 8.6	43.5 ± 6.0	NS

NS, non-significant.

## Discussion

Our study demonstrates a high frequency of continuous gas embolism during hysteroscopy, which is associated with a small but statistically significant increase in pulmonary artery systolic pressure without affecting right ventricular function. In 30% of patients, this finding was associated with a transient reduction in oxygen saturation.

Previous reports have documented the occurrence of gas embolism in patients undergoing hysteroscopy.<sup>4-6,9</sup> Bloomstone et al.<sup>7</sup> prospectively examined 11 women using tranthoracic echocardiography and demonstrated gas bubbles in the RA in 10 patients, a study supporting our findings. Our study extends their findings by describing the amount of time the bubbles were present relative to the length of the procedure and correlating them with haemodynamic changes. Although the increase in pulmonary pressure was modest and did not result in haemodynamic impairment in any of the patients, the study population was healthy and free of cardiopulmonary disease. It is possible that patients with pulmonary hypertension at baseline undergoing the procedure may suffer from even a slight increase in pulmonary pressure and caution should be exercised in these patients. Another important subgroup of patients at increased risk for adverse events, specifically paradoxical embolism, given the findings of our study is patients with known significant intracardiac shunts.4,10,11

The limitations of our study include the lack of blinded interpretation of the echo results given the study design. In addition, not all study subjects had adequate measurement of TR gradients, due to the lack of significant TR in this young healthy population. Technical imaging was satisfactory in all patients. There is no reason to assume that the subgroup with measurements is not representative of the study cohort as a whole. We utilized TTE imaging to assess gas embolism. While transesophageal echocardiography (TEE) is considered the gold standard for the detection of intracardiac gas embolism, recent studies have shown excellent sensitivity for TTE which is comparable to TEE.<sup>12–14</sup> It is therefore unlikely that the incidence of gas embolism was underestimated in our study.

In conclusion, operative hysteroscopy is associated with a high frequency of gas embolism, which may be associated with slight increases in pulmonary artery pressure, which in our study were not clinically significant. Physicians caring for these patients should be aware of this potential complication.

#### Conflict of interest: none declared.

#### References

- Loffer FD. Laser ablation of the endometrium. Obstet Gynecol Clin North Am 1988; 15:77–89.
- Jansen FW, Vredevoogd CB, Van Ulzen K, Hermans J, Trimbos JB, Trimbos-Kemper TC. Complications of hysteroscopy: a prospective, multicenter study. Obstet Gynecol 2000;96:266–70.
- 3. Garry R. Endometrial laser ablation. *Gynecol Obstet* 1994;2:188-95.
- Rademaker BMP, Groenman FA, van der Wouw PA, Bakkum EA. Paradoxical gas embolism by transpulmonary passage of venous emboli during hysteroscopic surgery: a case report and discussion. Br J Anaesth 2008;101:230–3.
- Groenman FA, Peters LW, Redemaker BMP, Bakkum EA. Embolism of air and gas in hysteroscopic procedures: pathophysiology and implication for daily practice. *J Minim Invasive Gynecol* 2008;**15**:241–7.
- Stoloff DR, Isenberg RA, Brill AI. Venous air and gas emboli in operative hysteroscopy. J Am Assoc Gynecol Laparosc 2001;8:181–92.
- Bloomstone J, Chow CM, Isselbacher E, VanCott E, Isaacson KB. A pilot study examining the frequency and quantity of gas embolization during operative hysteroscopy using a monopolar resectoscope. J Am Assoc Gynecol Laparosc 2002;9: 9–14.
- Lew TWK, Tay DHB, Thomas E. Venous air embolism during caesarian section: more common than previously thought. *Anesth Analg* 1993;77:448-53.
- Nachum Z, Kol S, Adit Y, Melamed Y. Massive air embolism—a possible cause of death after operative hysteroscopy using a 32% dextran-70 pump. *Fertil Steril* 1992;58:836-8.
- Cucciara RF, Nugent M, Seward JB, Messick JM. Air embolism in upright neurosurgical patients: detection and localization by two-dimensional TEE. *Anesthesiology* 1984;60:353.
- 11. Muth CM, Shank ES. Gas embolism. N Engl J Med 2000;342:476-82.
- Clarke NR, Timperley J, Kelion AD, Banning AP. Transthoracic echocardiography using second harmonic imaging with valsalva maneuver for the detection of right to left shunts. *Eur J Echocard* 2004;5:176–81.
- Daniels C, Weytjens C, Cosyns B, Schoors D, De Sutter J, Paelinck B et al. Second harmonic transthoracic echocardiography: the new reference screening method for the detection of patent foramen ovale. Eur J Echocard 2004;5:449–52.
- Kuhl HP, Hoffman R, Merx MW, Franke A, Klotzsch C, Lepper W et al. Transthoracic echocardiography using second harmonic imaging: diagnostic alternative to transesophageal echocardiography for the detection of atrial right to left shunt in patients with cerebral embolic events. J Am Coll Cardiol 1999;34:1823–30.