

Occurrence of a carbon dioxide embolism during laparoscopic pyloromyotomy in a small child: several unresolved questions

Marc Fischler, MD

Received: 20 October 2010 / Accepted: 9 November 2010 / Published online: 4 December 2010
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To the Editor,

We read with great interest the article by Drs. Taylor and Hoffman who reported the case of a major carbon dioxide (CO₂) embolism in a two-week-old neonate during laparoscopic pyloromyotomy.¹ This case raises several issues. First, the authors stated that there are sporadic reports of deaths in humans associated with massive CO₂ embolism; however, it is important to bear in mind that recent studies performed in adult patients have shown a high prevalence of gas embolism during laparoscopic procedures when using transesophageal echocardiography as the diagnostic tool. All patients undergoing total laparoscopic hysterectomy suffered a right atrial gas embolism, and one-third of these underwent a high-grade gas embolism.² Seventeen percent of patients undergoing a laparoscopic radical prostatectomy also suffer a right atrial gas embolism.³ It is unknown whether high rates such as these are encountered in the pediatric population. Second, the high solubility of CO₂ does not necessarily confer a protective effect against coronary or cerebral embolisms. The use of CO₂ as an alternative to iodinated contrast media for angiography has shown slow dissolution in blood, i.e., occurring within two to three minutes.⁴ Tissue damage could be explained by several mechanisms: vascular obstruction; transformation of gas bubbles in non-emboli gas, particularly with platelet adhesion; local toxicity of CO₂; and local and general inflammatory response.⁵ Finally, many small children have an atrial shunt, as in the reported case. It would seem logical to consider these points when choosing between a laparotomy and a laparoscopic approach to surgery.

M. Fischler, MD (✉)
Hôpital Foch, Suresnes, France
e-mail: m.fischler@hopital-foch.org

Competing interests None declared.

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Reply

We thank Dr. Fischler for his interest in our case report.¹ As he states, recent studies demonstrate a high prevalence of gas embolism detectable by transesophageal echocardiography. This includes some "high grade" emboli, defined by Kim *et al.*² as detectable gas in excess of half the diameter of the right atrium, right ventricle, or right ventricular outflow tract. The actual volume of the emboli detected in this study was not quantified. The remarkable ability of mammals to clear gas from the circulation has been demonstrated in several animal studies and may help to explain the infrequent occurrence of morbid events. In a piglet model, the continuous infusion of 0.75 mL·kg⁻¹·min⁻¹ carbon dioxide (CO₂) resulted in pulmonary hypertension,

acidosis, and hypoxemia; however, no deaths occurred until the infusion rate was increased to $1.2 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$.³ Another study involving intravenous infusion of air in dogs at a rate of up to $0.30 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$ demonstrated the ability of the lungs to filter venous air effectively and to prevent its passage to the arterial circulation. Spillover occurred in 50% of the animals at an infusion rate of $0.35 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$, and in over 70% of the animals when the infusion rate was increased to $0.4 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$.⁴

Persistence of CO_2 may contribute to transient organ dysfunction and even cardiac arrest, but clearance of gas within minutes should not result in sustained cardiovascular collapse in the setting of effective cardiopulmonary resuscitation. Although CO_2 might have a greater “therapeutic window” than air, both gases can cause injury with massive embolism. Small emboli create a significantly greater risk in the presence of right to left shunting, and Dr. Fischler correctly points out the high frequency of atrial shunts in children. In an echocardiographic study of “innocent” murmurs in infants, Arlettaz⁵ found that all babies with a murmur at birth had a patent foramen ovale, which persisted in two-thirds of the infants at six weeks-of-age. In contrast, only one-third of the control population (no murmur at birth) had echocardiographic evidence of shunting at the atrial level. Unless the frequency of clinically significant emboli during laparoscopy is sufficiently high, the presence of intracardiac shunting may not

preclude the use of laparoscopic techniques; however, as Dr. Fischler wisely suggests, the presence of an atrial shunt should be considered when evaluating the relative benefits of laparoscopy.

Susan P. Taylor, MD

George M. Hoffman, MD

Children's Hospital of Wisconsin, Milwaukee, USA

Competing interests None declared.

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