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Anesthesiology  
66:234-235, 1987

## Transient Hypoxemia from a Transient Right-to-Left Shunt in a Child During Emergence from Anesthesia

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Hypoxemia during and after anesthesia may be secondary to a number of changes in the circulatory and respiratory systems.<sup>1</sup> We have observed that some infants develop signs of hypoxemia (cyanosis, decreased transcutaneous PO<sub>2</sub>, decreased arterial saturation) during emergence from anesthesia. This decrease in oxygenation occurs despite continued ventilation of the lungs with 100% oxygen. We speculate that straining against a tracheal tube causes increased airway resistance and pulmonary vascular resistance. Consequently, a right-to-left intracardiac shunt at the atrial level could occur in patients with a persistent foramen ovale. The following case report demonstrates such a phenomenon.

### REPORT OF A CASE

The patient was a 13-month-old male child who previously had two uneventful general anesthetics. The patient underwent inhalation

anesthesia for eye examination and possible lens aspiration. The pre-anesthetic examination showed a normally developed patient with left microphthalmia, with clear lungs on auscultation and no cardiac murmurs. Following induction of anesthesia with halothane nitrous oxide oxygen, an iv catheter was inserted. Atropine 10 µg/kg, thiopental 4 mg/kg, and succinylcholine 2 mg/kg were administered iv. The trachea was intubated with a 3.5 mm I.D. tracheal tube. In addition to the usual monitors, we used a pulse oximeter (Nellcor® B-100, Nellcor, Inc., Hayward, CA). Following tracheal intubation, the lungs were ventilated with an inspired oxygen concentration of 35%, resulting in an arterial oxygen saturation of 99%. Twenty-five minutes after endotracheal intubation and during the eye examination, the patient began to cough and strain against the tracheal tube. The arterial oxygen saturation rapidly declined to 63%, despite ventilation with 100% oxygen. Arterial saturation increased to 99% with continued ventilation with 100% oxygen. The level of anesthesia was deepened by increasing the inspired halothane concentration, and the procedure was continued. During emergence from anesthesia, the patient again strained and coughed against the tracheal tube. Arterial saturation decreased to 80%. At that time, a contrast echocardiogram with stirred saline revealed a right-to-left shunt at the atrial level (figs. 1 and 2). No shunt was present when the child was not straining. A chest radiograph showed the tracheal tube to be in the mid-trachea, and the lung fields were clear. The arterial saturation again increased to 99% within 1 min by continued ventilation with 100% oxygen. The trachea was extubated when the child was fully awake. The post-anesthesia recovery period was uneventful.

### DISCUSSION

An interatrial right-to-left shunting has not been described as a cause of hypoxemia associated with emergence

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Key words: Anesthesia; pediatric. Complications: hypoxemia. Heart: patent foramen ovale.

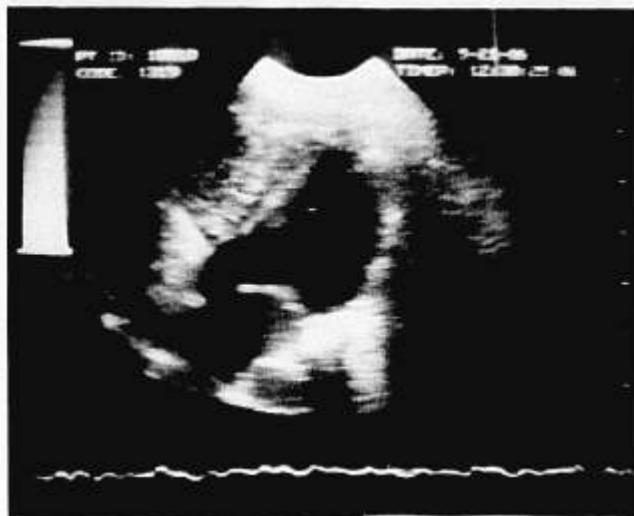


FIG. 1. Contrast echocardiogram with stirred saline indicating a shunt at atrial level. The echoes rapidly entered the left ventricle from the left atrium. The four chamber picture shows contrast echoes from right atrium, right ventricle, and left ventricle.

from endotracheal anesthesia. During the early phases of emergence, patients cough and strain, and ventilation may be difficult. The decline in oxygenation, however, may not be due entirely to decreased ventilation from the difficulty to ventilate the lungs using positive pressure. The contrast echocardiogram in our patient demonstrated a right-to-left shunt at the atrial level, indicating a functional foramen ovale. During straining and coughing, intraabdominal pressure rises, the diaphragm is pushed upward, lung volumes are reduced, airway closure occurs, and pulmonary vascular resistance increases.<sup>2</sup> As right atrial pressure increases, a right-to-left interatrial shunt occurs. Approximately 34% of children have a patent foramen ovale during the first decade of life.<sup>3</sup> Both a patent foramen ovale and a change in the right atrial pressure with a reversal of the normal right atrial to left atrial pressure gradient must be present for the development of a right-to-left shunt producing hypoxemia. The contrast echocardiogram is a rapid and safe method of demonstrating right-to-left intracardiac shunts.<sup>4</sup>

In summary, we present a child with transient hypoxemia during emergence from anesthesia. The cause of the hypoxemia was documented with a contrast echocardiogram to be a transient right-to-left atrial shunt. We

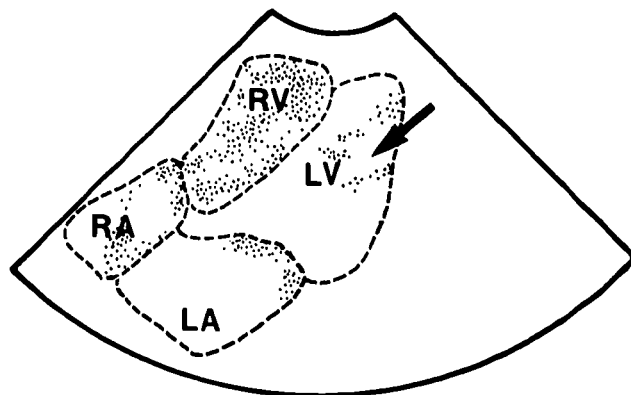


FIG. 2. A diagram of the contrast echocardiogram shown in figure 1. Arrow points to the place of contrast echoes in the left ventricle. RA = right atrium; RV = right ventricle; LA = left atrium; LV = left ventricle.

recommend that the lungs be fully ventilated with 100% oxygen throughout the period of emergence from anesthesia to reduce the incidence and severity of hypoxemia. Failure to ventilate the patient's lungs with 100% oxygen may permit alveolar hypoxia to occur, which, in combination with hemodynamic effects of coughing and straining, can result in pulmonary vasoconstriction, increased right atrial pressure, and an interatrial right-to-left shunt with profound hypoxemia in those patients who have a persistent patent foramen ovale. The presence of a right-to-left intracardiac shunt can lead to paradoxical air embolism from air accidentally administered with intravenous fluids.

The authors thank Ms. Cindy Finchum for helping with the echocardiogram and Dr. Ellis, Professor of Ophthalmology, for allowing the authors to study this patient.

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