Title: DOES A LEFT-TO-RIGHT SHUNT SPEED THE INDUCTION OF INHALATIONAL ANESTHESIA IN CONGENITAL HEART DISEASE?

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Introduction. The effect of a left-to-right (L-to-R) shunt on the speed of induction of inhalational anesthesia is a subject of controversy. Some investigators have stated that a L-to-R shunt results in a more rapid induction. Others state that it has no effect. To clarify these issues, a set of computer simulations was performed to explore the effects of L-to-R shunts in different circumstances and with different anesthetics.

Methods. Using a computer model, the induction of a 7 year old child with congenital heart disease was simulated, with varying combinations of L-to-R and R-to-L shunts. N₂O, halothane, and diethyl ether were modeled. In these simulations, inspired concentration and alveolar ventilation were held constant.

Results. The simulations led to 4 conclusions: 1) A L-to-R shunt results in a small, but clinically insignificant, increase in the speed of induction of anesthesia in the presence of a physiologic (5%) R-to-L shunt (Fig. 1). 2) In the presence of a large (50%) R-to-L shunt, however, which by itself will slow induction, the addition of a L-to-R shunt will significantly speed induction (Fig. 2). A clinical example of this phenomenon is a child with Tetralogy of Fallot (R-to-L shunt) who has had a Blalock-Taussig procedure creating a L-to-R shunt. 3) A large L-to-R shunt which results in reduced systemic blood flow will result in a faster induction as is seen with a low cardiac output. 4) The effects of shunts are more pronounced with N₂O than with halothane or ether.

Discussion. The speed of induction of an inhalational anesthetic is determined by three rates:

1) the rate of anesthetic inflow into the lungs,
2) the rate of anesthetic transfer from the lungs to the arterial blood,
3) the rate of anesthetic transfer from the arterial blood to the tissue.

The effect of a circulatory shunt on the induction of a specific anesthetic depends on how it alters these three rates. A L-to-R shunt results in an increase in rate 2. When combined with a physiologic (5%) R-to-L shunt, (which results in only a small alveolar-to-arterial anesthetic gradient), the L-to-R shunt cannot cause a significant increase in the arterial anesthetic concentration. When combined with a large (50%) R-to-L shunt, however, (which decreases rate 2 by diverting blood away from the lungs), the L-to-R shunt raises pulmonary flow and thereby increases rate 2.

When the L-to-R shunt does speed induction, the effect is more pronounced with N₂O than with halothane or ether because of its lower solubility. The induction with a highly soluble anesthetic is limited by ventilation (rate 1). Therefore, a decrease in rate 2 (caused by the R-to-L shunt) will not have a dramatic effect on speed of induction. In contrast, for an anesthetic of low solubility rate 2 is the limiting rate. A change in this rate will have a significant effect on induction.

Conclusion. These simulations confirm the statement of some investigators that, in an otherwise normal patient, a L-to-R shunt does not have a clinically significant effect on the speed of induction of inhalational anesthesia. The simulations do, however, point out two circumstances in which a L-to-R shunt may speed induction: 1) when it coexists with a large R-to-L shunt, 2) when tissue perfusion is not maintained. These effects are more pronounced with less soluble anesthetics.

Figure 1.

Figure 2.