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Editorial Views

A Second Lung

IN THIS ISSUE of the Journal Folkman and Winsey describe the intravenous induction of anesthesia with volatile anesthetics via an arteriovenous shunt made of silastic rubber. In effect, these workers have created a "second lung" through which anesthesia may be achieved with very potent blood-soluble anesthetics. This "second lung" differs from the natural one. The wall of the shunt separating anesthetic and blood is thicker than the alveolar-capillary membrane; this barrier produces a large gradient between the partial pressure anesthetic outside the shunt and that within the blood. The reduction in partial pressure of anesthetic dissolved in blood is necessary to prevent hemolysis. But the large gradient has other implications. For a given shunt, the volume of anesthetic absorbed per minute is essentially constant and is determined by the relative thinness of the shunt and the surface area exposed. It is unaffected by wide changes in blood flow. Blood perfusing the "second lung" also differs from that in the natural lung in that equilibration with the anesthetic adjacent to the inner wall of the shunt is incomplete. This is a result of the length of the diffusion pathway (1.3 mm. to the center of the stream) and rapidity of passage of blood through the shunt (about half a second).

The authors suggest several uses for these "second lungs." For example, they may permit attainment of anesthesia with extremely potent soluble anesthetics which currently are not applicable for clinical use because of prolonged induction and recovery times. Such agents are known, but unfortunately their vapor pressures may be less than those required for production of anesthesia. Even if anesthesia could be produced, one may ask if the administration of a very soluble volatile agent via a shunt has any advantage over the intravenous injection of fixed agents such as opiates?

Although this technique easily produces general anesthesia with methoxyflurane, the necessity for creation of arteriovenous shunt may preclude its widespread clinical application for this purpose. However, the technique readily lends itself to the chronic administration of anesthetics and this, the authors suggest, may render it useful outside the operating room. It may serve to produce prolonged analgesia in cancer patients suffering intractable pain. It may be used to treat leukemia or to suppress immune reactions such as those causing rejection of transplanted tissues. However, the benefits of chronic administration may carry an unacceptably high price. Suppression of replication is not limited to leukemic cells but applies to most growing tissues. Thus fetal development may be impaired,[1] hematopoiesis reduced, and neutropenia result from the prolonged administration of anesthetics.[2, 3]

Another hazard may arise in the very factors which serve to limit the level of analgesia. As Folkman and Winsey observed, a shunt which produces analgesia acutely in dogs weighing from 16 to 18 kg. produces deep surgical anesthesia in dogs of 15 kg. and less; with chronic administration, this may be a still greater problem. The major portion of anesthetic elimination occurs via metabolism or pulmonary ventilation; either pathway may vary in effectiveness with time. Significant metabolic conversion of anesthetics occurs acutely [4]; will chronic administration stimulate or enlarge this pathway? Ventilation varies with the circumstance, increasing with activity and decreasing with sleep; will this have an inverse influence on the anesthetic level? If the anesthetic level deepens because of decreased ventilation, will the deeper level produce a further reduction in ventilation and deepening of anesthesia? This possibility of positive feedback must be forestalled, therefore, perhaps by limiting the amount of anesthetic surrounding the shunt at any one time.

These shunts may also serve as "second lungs" for uptake of oxygen and elimination of carbon dioxide. Such a use might enable infants with the respiratory distress syndrome to survive until their own lungs functioned adequately. Similarly, emphysematous patients with terminal respiratory insufficiency might be sustained until lung transplantation could be performed (administration of anesthesia for the transplantation procedure might be a bit complex). These "second lungs" suggest even more exotic possibilities, such as "gills" for man in the sea. However, none of these possibilities is immediately feasible because the currently employed shunts do not permit adequate volumes of oxygen to be transferred to blood. This results from the limitation of diffusion imposed both by the silastic membrane [5] and by the thick layer of blood which the gas must penetrate.

Discovery of a new technique such as a "second lung" may bring applications beyond the technique's original purpose. However, these applications could founder because of insoluble complications.

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References

1. Fink, B. R., Shepard, T. H., and Blandan, R. J.: Teratogenic activity of nitrous oxide, Nature 214: 146, 1967.
2. Lassen, H. C. A., Henriksen, E., Neubirch, R., and Kristensen, H. S.: Treatment of tetanus: Severe bone marrow depression after prolonged nitrous oxide anaesthesia, Lancet, 270: 527, 1956
3. Green, C. D., and Eastwood, D. W.: Effects of nitrous oxide inhalation on hemopoiesis in rats, Anesthesiology 24: 341, 1963.
4. Rehder, K., Forbes, J., Alter, H., Hessler, O., and Stier, A.: Halothane biotransformation in man: A quantitative study, Anesthesiology 28: 711, 1967.
5. Ruedi, B., and Fleisch, A.: Diffusion des gas a travers des membranes plastiques minces, Helv. Physiol. Acta, 20: 193, 1962.