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Editorial Views

Is Thought Free?

CONSIDERABLE EFFORT has been devoted to elucidating the mechanisms by which general anesthetics alter metabolic function. In an article in this issue,[1] Theye poses several fundamental questions: 1) Which organ or organs participate in the decreased oxygen uptake observed during halothane anesthesia? 2) Do all organs alter their metabolic needs to the same extent during halothane anesthesia? 3) Can decreased metabolic demands be related to changes in organ function?

In this study, as in a previous investigation,[2] a significant dose-related decrease of whole-body and myocardial oxygen uptake accompanied halothane anesthesia. The important contribution of the present work resides in the utilization of these data to quantify the contributions of skeletal muscle, cardiac muscle, splanchnic bed, brain, and kidney to this metabolic change. The data indicate strikingly that decreased oxygen utilization is not uniform throughout the body. While decreased myocardial oxygen consumption contributed almost 50 per cent to lowered whole-body oxygen utilization, the effect of halothane on cerebral oxygen requirements contributed only 2 per cent. In table 1, I have illustrated the author's data in an alternate fashion by expressing each organ's oxygen usage as a percentage of total oxygen uptake. Oxygen uptake of each organ studied decreased in the presence of an end-tidal halothane concentration of 1.5 per cent. While the per cent decrease in myocardial oxygen utilization far exceeded the per cent change in whole-body oxygen uptake, alterations in metabolic rate in the other organs examined were less than that observed in the body as a whole. In control animals, myocardial oxygen consumption comprised 21.7 per cent of total oxygen uptake; in animals anesthetized with 1.5 per cent halothane, myocardial oxygen uptake was only 12.1 per cent of the total. On the other hand, the ratio of cerebral oxygen usage to whole-body oxygen consumption remained fairly constant in anesthetized animals.

What is the significance of these findings? During halothane anesthesia, myocardial work decreased profoundly, a phenomenon accompanied by a major reduction in metabolic needs. An end-tidal concentration of 1.5 per cent halothane was accompanied by a change in myocardial oxygen uptake from 1.40 to 0.57 ml/min/kg, a value of 41 per cent of control. At the same time, left ventricular external work (which comprised more than 85 per cent of total cardiac work) declined to 29 per cent of control. Whether this discrepancy between myocardial work and myocardial oxygen uptake represents altered myocardial efficiency related to the anesthetic or lack of precision of methods of measurement remains to be determined.

While the relationship of halothane's effect on myocardial oxygen utilization to myocardial function is obvious, similar consideration of other organs is less clear. Data presented in table 1 indicate that the ratio of skeletal-muscle to whole-body oxygen utilization was unaffected by halothane anesthesia. Undoubtedly, these findings would have been markedly different had the control animals been exercising rather than resting. What of the effects on the functions of other organs?

TABLE 1. Ratio of Organ to Whole-body Oxygen Uptake (Expressed as Percentage)

	Expired Halothane Concentration	
	<0.2 Per Cent	1.5 Per Cent
Myocardial	21.7	12.1
Splanchnic	27.6	34.4
Renal	6.5	7.0
Cerebral	3.4	3.8
Skeletal muscle	35.0	39.3
Other tissues (difference)	5.8	3.4

Deutsch[3] and Price[4] have shown that the functions of kidney and liver are considerably affected by halothane. In the case of these organs, however, work is far more difficult to quantitate. While changes in muscular activity accompanying anesthesia give rise to well-defined changes in oxygen uptake, the relationship between decreased hepatic excretion of indocyanine green[4] and splanchnic oxygen utilization is far more subtle. Nonetheless, it is reasonable to suppose that the contributions of the splanchnic and renal beds to decreased whole-body oxygen uptake have their counterparts in decreased function.

Some discussion concerning the effects of anesthetics on cerebral oxygen utilization is warranted. Inhalation of halothane resulted in an 18 per cent decrease in cerebral oxygen utilization. Since a major function of the brain is maintenance of consciousness, is it not likely that the decrease in brain oxygen consumption represents an absence of this vital process? In the present work, the author states that altered cerebral states such as sleep and schizophrenia are not accompanied by changes in cerebral oxygen utilization. It must be stressed that these conclusions stem from examination of whole-brain oxygen utilization. More recent investigations of regional cerebral function have disclosed significantly different results. Ingvar[5] measured regional blood flow of normal man both at "mental rest" and while doing mental arithmetic. The performance of this task resulted in an 8 per cent increase in cerebral blood flow and presumably, cerebral oxygen uptake in certain areas of grey matter. Similar studies in animals have disclosed an increase in occipital blood flow during photic stimulation. These changes related to alterations in regional function may be masked by the unaffected metabolism in the remainder of the brain, and may therefore have little effect on measured total cerebral oxygen usage.

To answer the question heading this editorial: *thought is not free.* Energy is needed for cerebral function, as it is for the functions of all organs. The effect of a given anesthetic on oxygen usage by a particular organ depends upon the way in which the drug alters the organ's function. Thus, an agent exerting the profound hemodynamic effects of halothane might be expected to manifest its most profound metabolic influence in the myocardium. Other drugs without this characteristic would not produce a similar phenomenon. Finally, the data in table 1 indicate that the effect of halothane on cerebral oxygen utilization is similar to its effects on other organs not performing external work. A disconcerting corrollary of this similarity might be that the same magnitude of energy is expended when a symphony is composed, indocyanine green is excreted, or urine is concentrated.

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