Low flow anesthesia and volatile anesthetic agents - Concerns

There is renewed interest in low flow anesthesia in clinical practice because of its subtle advantages and the availability of better techniques and monitoring devices. The advantages of low flow anesthesia include cost saving, prevention of environmental pollution, and clinical advantages such as lesser loss of heat and moisture. However, one should be cautious about risk of hypoventilation from leaks, the large volume of the system, the discrepancy between the delivered fraction and the inspired fraction of inhaled gases and the accumulation of toxic compounds. These factors can be easily tackled if one understands the basic principles of low flow anesthesia. Lack of awareness and possibly concern regarding its safe use may be the limiting factors for its widespread use. It has been reported that educating the anesthesiologists was effective in reducing the fresh gas flows used (fractional reduction of fresh gas flow of 21% after education).

In this issue of the journal, Mallik et al. report a comparative evaluation of two volatile anesthetic agents in minimal flow anesthesia. They compared the mean equilibration time of volatile inhalational agent and mean end-tidal volatile anesthetic partial pressure. The switch over of flows from high to low after anesthesia induction and again to high at the end of anesthesia is always a concern. Various techniques like fixed time frame, inspired/expired concentration of volatile agent and more recently Gasman simulation model have been proposed to guide the maintenance of low flow anesthesia. Although many mathematical and non-mathematical calculations have been described in literature to achieve satisfactory anesthesia at low flows, there is no consensus regards the best method to be followed.

The authors of the present study observed that nitrous oxide showed a falling trend over time. This finding should be considered with caution especially with minimal flow anesthesia. During the initial phase nitrous oxide is taken up by the body but later on it tends to recirculate in the breathing system since it has minimal metabolism and is excreted primarily though respiratory system. Oxygen is consumed by the body tissues and thus tends to have decreasing trend over time. This consumption of oxygen should be catered for when using low flow anesthesia to avoid hypoxic mixture, thus mandating monitoring of inspired as well as expired oxygen concentration. A practical solution to this issue is calculating the oxygen consumption of the patient and subtracting this from the desired fresh gas flow. The remaining fresh gas flow, composed of oxygen and nitrous oxide in the desired ratio, is added to the calculated sum.

Some anesthesia workstations with algorithms for a closed loop control of end-tidal concentrations of oxygen and volatile agents are available. On these machines the desired target can be set according to patient need and the machine automatically adjusts the delivery of oxygen and anesthetic agents. The uptake of volatile agent is low at fresh gas flow and thus there is a discrepancy between vaporizer dial settings and inspired/end tidal vapor partial pressure. This mandates the need of gas agent monitor during the practice of low fresh gas flow anesthesia. Vaporizers are designed for use with high fresh gas flows with a consequent requirement for high thermal capacity, temperature compensation, and high accuracy. The use of low carrier gas flows makes these characteristics unnecessary and introduces the problem of delivering an adequate quantity of...
volatile agent into the breathing system. A long time constant is a practical disadvantage of low-flow techniques using current vaporizers. A pragmatic solution is to increase the carrier gas flow for a time, but this leads to venting of gas and consequent wastage. The anesthetic potency of the volatile agents have an impact on the delivery of the anesthetic vapors and it has been observed that the maximum concentration which can be set on vaporizer limited to 3-5 times of its MAC. Low anesthetic potency and low solubility essentially improve the control during performance of low flow techniques. There is a need to modify the vaporizers design for better efficiency during low flow anesthesia. The direct addition of liquid agent, which permits rapid increases in concentration with no need to adjust the carrier gas flow, could be one of the options.

The need of ‘minimal mandatory oxygen bleed’, which is mandatory in anesthesia workstations, appears to be redundant with use of low flow anesthesia. Another concern during anesthetic management is about clinical parameters affecting the partial pressure of volatile anesthetic agents such as increase in requirements during intense surgical manipulations or decrease in requirement when anesthetic adjuvants like opioids are used.

Certain degradation products may give a ‘mixed agent’ warning due to absorption of infra-red light similar to some other volatile agent as production of Methanobacterium ruminatum mimics halothane. It has long been recognized that the chemicals used to absorb carbon dioxide may react with volatile anesthetic agents. With the discovery that the strong alkalis used in carbon dioxide absorbers are responsible in the production of both carbon monoxide and compound A, modifications have been done in circle absorbers. Non-chemical systems for carbon dioxide removal are currently being developed and evaluated.

Low flow anesthesia deserves a prime place in the clinical anesthesia practice. Anesthesiologists should understand its basic principles with regards to volatile agent used, alteration of flows and vaporizer dial settings along with suitable monitoring and its interpretation.

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