Evolution of low-flow anaesthesia

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General anaesthesia (GA) using volatile anaesthetics (VAs) is primarily practised worldwide. Started "officially" in 1846 by William T. Morton with nitrous oxide (N_2O), this VA-based GA spread rapidly due to its apparent simplicity and ease of use.[1] Unfortunately, lack of proper monitoring and other technical difficulties led to many accidents and even deaths along the way, with the first case recorded in 1848.[1] The main difficulty was measuring the concentration of different VAs and evaluating the depth of anaesthesia.

In the early '60s, the first gas analysers appeared.[2] Later, a term called mean alveolar concentration (MAC) appeared. It offered a quantitative measurement of the VA concentration in the lung as an indirect indication of VA concentration in the brain, the target organ.[3,4] The quality of the VA evolved too. Halothane was replaced in the early 80s by isoflurane. Shortly after, sevoflurane appeared and spread rapidly into clinical use. Desflurane is another VA with good physical properties.[5] Historically, N_2O has been and is still used because of its "potentialising" properties. The early VAs were not potent enough, so N_2O was added. The modern VA does not need it; they are powerful enough, yet some clinicians still use it for "traditional" reasons.

The evolution of our understanding and monitoring brought the question of whether we need the high initial flows traditionally used in anaesthesia. Slowly, a new concept appeared in the lexicon of anaesthesiologists: low-flow anaesthesia (LFA). The term "low" refers to the levels of gas delivered that were now measured and proved sufficient to provide the patient with the correct quantity of VA. Anything more than this was just wasted as part of it filled unnecessarily different body compartments; part was wasted into the atmosphere. The LFA has practical anaesthetic advantages as lower quantities of gas are delivered to the patient. LFA has positive economic and environmental effects, too. Economies up to 80% can be reached when using LFA compared to the previous higher flows. Less VA evacuated into the atmosphere means less greenhouse effect. The contribution of the VA to this effect seems minor, but it adds up. Using LFA helps the anaesthesiologist avoid using another environmentally detrimental gas, N_2O, with an estimated atmospheric life of over 100 years. Despite all these positive implications of LFA, its clinical implementation has been hindered by several difficulties.

VAs are all invisible gases; they are not seen. It is mentally challenging to comprehend their spread both in the operating rooms and outside the hospital. LFA was initially applied using complicated mathematical models as modern gas analysers were missing. This reality was not attractive to the anaesthesiologists. The appearance of the gas analysers was a game changer. Unlike intravenous medications, where the plunger goes down the syringe, we do not see the VA. In the best situation, we only see a number on the monitor, the MAC. Another discouraging factor is the economic one: an anaesthesia monitor with a gas analyser that measures all the VA appears to cost double that of the one that only shows the end-tidal carbon dioxide ($EtCO_2$). Modern anaesthesia workstations address this issue. The gas analyser is a built-in part of the machine. Other machines add a feature that shows the evolution of the MAC in the brain, the target organ. This helps the anaesthesiologist understand the movement of VA within the whole system, both the machine and the body. Thus, the GA can be better individualised, avoiding over- or under-delivery of VA. Other modern anaesthesia workstations display an "Economizer" indicating if the flow is correct, over, or lower than needed.

LFA has recently seen a revival trend. More literature appears, transforming the previously mentioned complex formulas into something easier to understand and apply.[6-8] An interactive computer program with an accompanying workbook is a great way to start, understand, and apply the LFA.[9] Unfortunately, the landscape of the anaesthetic world varies largely. Lack of financial means, scarce oxygen resources, and non-existing or un-serviced anaesthesia workstations and monitors do not allow the spread of the LFA in many regions. Time, effort, education, and finances are required to help LFA penetrate our common practice on a larger scale. Ultimately, all success is achieved through a combination of the human factor and technological advancement.

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