Validating the two-box model: overall fresh gas flow and characteristics of the initial high flow period are both useful markers of volatile anaesthetic consumption.

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Introduction: Volatile anesthetics are unique in that much of the agent admistered doesn't reach the patient. This waste has long been a concern, driven initally by economics but more recently by environmental concerns.
We have monitored fresh gas flow (FGF) rates as a marker of efficiency of volatile delivery for over two decades, while recognising that this is a surrogate for the actual vapour consumption. In 2017 we introduced the concept of the "two-box model" of FGF which emphasises the large contribution of FGF in the initial high flow period to overall average FGF (1). Over the past five years we have used GE Insights to monitor FGF patterns in many of our OR. This provides data on actual vapor consumption, FGF and a range other parameters. This allowed us to investigate the relationship between actual vapor consumption and 1) FGF and 2) the characteristics of the initial high flow period – the first box.

Methods: From the Insights data set we extracted cases between August 2018 and July 2023 lasting > 30min where sevoflurane was delivered for at least 1/3 of the case. Since actual sevoflurane use is the variable of interest, these cases were grouped by the total sevoflurane useage into 150 equal sized groups. We then explored the relationship between the group means of sevoflurane useage and 1) mean FGF and 2) the product of initial FGF and duration of the initial flow, defined in Insights as the period until FGF first falls below 5 l/min.

Results: We found 28,000 cases meeting our criteria. These had a mean duration of 95min and an overall time-weighted mean FGF of 0.934 l/min. Average consumption was 14.2ml of sevoflurane (2.8kg CO_2-equiv). We have data for 77 cases from the same period using desflurane with an average useage of 31.6ml (117kg CO_2-equiv).
As shown in the Figures, we found a strong positve correlation between sevoflurane consumption and both mean FGF (r^2 = 0.83) and [initial gas flow x initial flow duration] (r^2 = 0.92).

Conclusions: These results validate the use of fresh gas flow rates as a marker for efficiency of delivery of sevoflurane. They also support the concept behind the "two-box model": that both intial high flow rates and the time at these flows (area of the first box) are major drivers of overall vapor consumtion.
The lines of best fit suggest that changing the average FGF by 100ml/min alters sevoflurane consumption by 5ml and that a 1min change in duration or 1L/min change in FGF in the initial period equates to 1.7ml sevoflurane, or 20% of our average.
These results are not desgined as a comprehensive model, but to reinforce important, measureable, and modifiable factors influence vapour consumption.
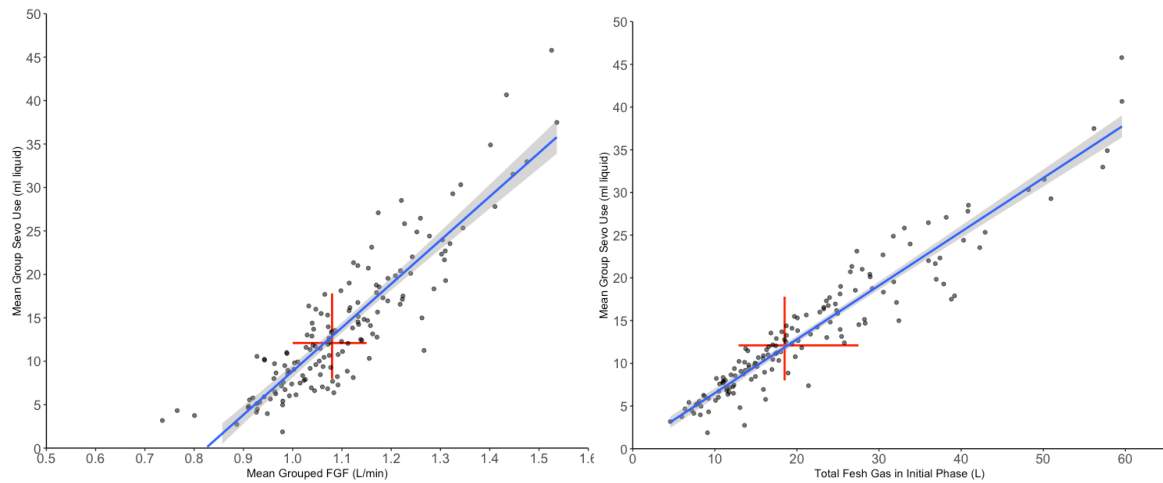
Figure: The relationship between mean FGF and ml of sevoflurane used (Left panel) and the product of FGF and time for the initial period with FGF above 5l/min(Right panel).
Blue line is the linear best fit: R^2 = 0.83 for overall FGF (left); R2 =0.91 for inital flows (right)
Red lines show the medians and interquatile ranges

Reference Kennedy RR, French RA, et al. The effect of fresh gas flow during induction of anaesthesia on sevoflurane usage: a quality improvement study. Anaesthesia. 2019;74:875-882.