Draft for submission, 8th July 2022

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Volatile agent capture – how to measure the success of a new technology?

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Keywords (MeSH): Global Warming; Carbon Footprint; Sevoflurane; Desflurane; Anesthesia; Technology

Editor – we read with enthusiasm the correspondence by Hinterberg and colleagues, describing a study of the clinical performance of volatile capture technology (VCT) based on activated charcoal (CONTRAfluran; ZEOZYS, Luckenwalde, Germany), in capturing desflurane.[1] We were, however, somewhat disappointed to learn that only 25% of the administered desflurane was captured.

Drawing on pharmacokinetic simulations, Hinterberg and colleagues propose that the differential distribution of desflurane amongst body compartments, and the rate of concentration change in those compartments (resulting in emergence from anaesthesia with a large proportion of desflurane still sequestered in the tissues), may explain the low percentage of desflurane capture observed in their study.[1] We agree with this reasoning, and would like to add some additional observations about the conduct of the study and the interpretation of the findings.

Hinterberg and colleagues' study was conducted using a median fresh gas flow of 0.8 $L.min^{-1}$ (interquartile range 0.5–0.8) and a median MAC of desflurane of 0.8 (0.8-0.9). Whilst this is slightly greater than the 'minimal' requirements for fresh gas flow and dose,[2] the volatile usage in this study was notably economical. This means that in the experimental conditions described, a lower proportion of volatile agent may have been wasted (and therefore available for capture) than might be expected in 'real world' clinical practice, where average fresh gas flows of over 1 $L.min^{-1}$ are frequently observed.[3,4]

The sole use of 'recapture rate' as the performance metric for VCT has the potential to create some perverse incentives. For example, if the fresh gas flow were 10 times greater than necessary, 90% of the administered agent would pass out of the circuit and into the VCT device intra-operatively, potentially leading to a higher recapture rate despite a clearly wasteful technique. This leads us to wonder whether describing the impact of VCT in terms of the overall carbon footprint of the technique, rather than recapture rate, may permit more meaningful comparisons.

As a worked example, Hinterberg and colleagues' data indicates that approximately 22g of desflurane was administered per hour of anaesthesia on average ((6902 g [of desflurane] / (238 min [median duration] x 80 [patients])) x 60). Based on the 100-year global warming potential (GWP_{100}) of desflurane (2540),[5] the environmental release of desflurane in this cohort would have a carbon footprint of 55.9 Kg CO_2e per hour without VCT, or 41.9 Kg CO_2e per hour if 25% is captured – a substantial reduction, but still equivalent to driving 213 miles in a typical new European car (122.3 g $CO_2e.km^{-1}$).[6]

Hinterberg and colleagues' note that 'we can expect the greatest environmental effects by using anaesthesia gas capture systems for desflurane'.[1] Whilst this may be true in terms of the performance of the technology, Hinterberg and colleagues' data makes it clear that the impact of VCT is grossly inadequate to offset the climate impacts of desflurane at low fresh gas flows. The GWP_{100} of the alternative agent, sevoflurane (144), is only 5.6% that of desflurane, and it is 3.7 times more potent (MAC of 1.8 vs 6.6), meaning that at equivalent fresh gas flows and MAC-equivalent doses, 98.5% of desflurane would need to be captured to 'break even' with sevoflurane used without VCT.[7] Considering that this proportion of capture seems unachievable, and given the lack of evidence for any clinical benefit of desflurane over alternative agents,[8] the work of Hinterberg and colleagues provides yet further evidence to support the abandonment of desflurane.

A modelling study by Hu and colleagues suggested that the use of VCT in combination with low-flow sevoflurane (0.5 $L.min^{-1}$ fresh gas flow) could bring the carbon footprint of sevoflurane-based anaesthesia below that of propofol-based total intravenous anaesthesia (TIVA).[9] However, this model assumed that 70% of sevoflurane would be captured, which seems less credible in light of the results presented by Hinterberg and colleagues.[1] Nevertheless, we believe that the primary role of VCT should be to offer a route to minimise the climate impacts of sevoflurane. Whilst the use of volatile anaesthesia seems to be diminishing as the popularity of total intravenous anaesthesia increases, it will always remain useful in certain circumstances (e.g., inhalational induction), and anaesthesia providers have a collective responsibility to mitigate its harmful effects.[10] Volatile capture technology could have a potentially-important role in this endeavour, for example by mitigating the effects of the (unintentional or deliberate) use of higher fresh gas flows – but more research is required to understand the magnitude of its effect. Importantly however, minimising the use of inhaled anaesthetic agents (e.g., through minimal fresh gas flows, end-tidal anaesthetic agent control and alterative techniques) remains the principal strategy in mitigating their environmental impacts.[10] In the waste hierarchy (Figure 1), 'reduce' quite rightly comes above 're-use' and 'recycle'.[10]

Declarations of interest

The authors declare no competing interests.

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Captions for Figure

Figure 1: a graphical representation of the 'waste hierarchy'.[10] Reduction takes precedence over reuse, followed by recycling; rethinking and research leads to the development of strategies for change.