Science Letter

Retained desflurane in decommissioned vaporisers: a national problem?

Desflurane has the highest 100-year global warming potential (GWP_{100}) of all the inhaled anaesthetic agents [1]. The standard NHS contract requires Trusts "*to reduce the carbon impacts from … environmentally damaging gases such as nitrous oxide and fluorinated gases*", and "*[reduce] the proportion of desflurane to all volatile gases used in surgery to 5% or less by volume*" [2]. An increasing number of Trusts are withdrawing desflurane.

Following the withdrawal of desflurane in the summer of 2022, our hospital needs to return the desflurane vaporisers to the drug manufacturer (D-Vapor 2000 and 3000, Dräger AG, Lübeck, Germany; on loan from Baxter Healthcare). The manufacturer requires the vaporisers to be empty when returned, but we found that all our decommissioned vaporisers contained some desflurane. This is now expired, so is unsuitable for clinical use.

Liquid desflurane can be drained from D-Vapor 2000 and 3000 vaporisers by inserting an empty desflurane bottle into the filling port and inverting the vaporiser [3,4]. According to the manufacturer, this will empty all but 30 ml of desflurane. However, this technique requires empty desflurane bottles, which cannot be purchased. Unfortunately, we did not retain any empty bottles when desflurane was decommissioned. An alternative method for removing desflurane (and the only way to remove the residual 30 ml following drainage) is to 'flush' the vaporiser with fresh gas via the anaesthetic machine and waste the desflurane to scavenging [3]. To quantify the potential carbon footprint of this approach, we measured the amount of desflurane in the decommissioned vaporisers at our institution, a large UK teaching hospital.

We identified 18 decommissioned desflurane vaporisers (17 D-Vapor 2000, one D-Vapor 3000). We selected the vaporiser (a D-Vapor 2000) with the lowest level of desflurane visible on the gauge, and ensured it was empty by placing it on the back bar of an anaesthetic machine (Perseus 500, Dräger AG), and flushing it with a fresh gas flow set to 12 $l.min^{-1}$ and the vaporiser set to 18%, until desflurane could no longer be detected by the gas analyser, then for another 5 min. The empty vaporiser was then weighed on a digital scale (MS4200, Marsden Weighing Machine Group, Rotherham, UK). The remaining 17 vaporisers were then weighed in order to calculate the mass of retained desflurane. Of note, the product literature states that the mass of the D-Vapor 2000 and 3000 are identical [3]. The weight of the empty vaporiser was 6.495 kg, 95 g more than specified in the product literature [3]; we believe this discrepancy is due to us including the 3-pin electrical plug in our measurements.

In total 3875 g of desflurane was retained in 17 vaporisers over a range of 50–500 g for each vaporiser. Based on the GWP_{100} of desflurane (2540), this would equate to 9.84 tonnes of CO_2 if emitted to the atmosphere, a potential 'carbon footprint' approximately equivalent to three return flights from the UK to Australia [5]. To estimate the potential scale of this problem, we multiplied the average mass of retained desflurane 'per theatre' (138.4 g) in our 28 operating theatres by the number of operating theatres in NHS England (3239) [6]. This approximate calculation suggests that 448 kg of desflurane (equivalent to 1139 tonnes of CO_2) may be retained nationwide.

The limitations of our study include an assumption (based on product literature) that the two vaporiser models weigh the same, and that one vaporiser (albeit one containing a negligible amount of desflurane) was emptied before measurement. When extrapolating our data to the national setting, we assumed that the ratio of retained desflurane to operating theatres in our hospital is representative, although this may not be the case.

Our findings should alert colleagues to the potential significance of retained desflurane. Anaesthetic departments should adopt a strategic approach to the decommissioning of desflurane, for example by working with colleagues to practice restraint in 'topping up' vaporisers, removing them from use one-by-one when nearly empty, and saving empty desflurane bottles to enable emptying. D-Vapor vaporisers have a 390 ml capacity, but based on our measurements and considering the density of desflurane (1.44 $g.l^{-1}$) [7], we suggest that one bottle (240 ml) per vaporiser is likely to be sufficient. If drainage is feasible, the residual 30 ml desflurane should also be considered, and this would have a CO_2-equivalent footprint of 109.73 kg per vaporiser.

The widespread reduction in desflurane use is cause for celebration. However, we must take care in how decommissioning is done to ensure that waste is minimised. Where waste is unavoidable, it should be handled responsibly. Draining desflurane into empty bottles allows vaporisers to be returned, but what to do with the desflurane bottles? A responsible disposal method for desflurane is required.

High-temperature incineration, emerging technologies such as photolytic destruction and volatile capture, and older technologies such as the Cardiff Aldasorber may have a role to play in the disposal of decommissioned desflurane, but their impacts need to be investigated [8,9].

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