Toward Greener Anaesthesia Practices: Mitigating the Environmental Impact

Inhaled anaesthetics, including volatile hydrofluorocarbons like desflurane, sevoflurane, isoflurane, and halothane, as well as nitrous oxide (N2O), have potent greenhouse gas properties, contributing significantly to global warming and ozone layer depletion. Despite efforts to mitigate their release through gas scavenging systems, these gases are ultimately released into the atmosphere. While their contribution to total global greenhouse gas emissions is relatively small, in clinical settings, they can account for a significant portion of emissions, including 50% of perioperative emissions, 5% of hospital emissions, and 3% of total national healthcare emissions. Desflurane, in particular, has the highest global warming potential and is primarily responsible for the greenhouse effect from volatile anaesthetic pollution. The American Society of Anaesthesiologists reflected on how to make the operating room greener.

Assessing Greenhouse Gas Potency and Atmospheric Lifetimes

The greenhouse gas potency of each anaesthetic agent is determined by its unique infrared absorption spectrum and atmospheric lifetime. Greenhouse gases absorb infrared radiation, trapping heat in the atmosphere, until they degrade. Inhaled anaesthetics, due to minimal metabolism during clinical use, remain intact upon release. Atmospheric lifetimes vary: desflurane (14 years), isoflurane (3 years), sevoflurane (2 years), and nitrous oxide (114 years). Global warming potential (GWP) measures a gas's contribution to warming over 100 years. Desflurane has the highest GWP (2,540), followed by isoflurane (539), nitrous oxide (273), and sevoflurane (144), subject to updates due to changing atmospheric chemistry.

Factors Driving Anaesthetic Emissions

Studies comparing the environmental impact of anaesthetic agents in clinical practice highlight two key factors driving emissions: the choice of anaesthetic agent based on its greenhouse gas potency (GWP) and the total amount used and released. Anaesthetic consumption depends on fresh gas flow rates and clinical potency (mean alveolar concentration [MAC]). Desflurane, with the highest GWP and lowest potency, requires higher concentrations compared to sevoflurane or isoflurane for an equivalent effect. Nitrous oxide, despite a lower GWP than isoflurane, is often used at concentrations leading to higher environmental impact.

Considering Life Cycle Emissions and Mitigation Strategies

While global warming potential (GWP) is important, a comprehensive assessment of anaesthetic gases considers cradle-to-grave life cycle emissions, including manufacturing, packaging, and transportation. A study comparing inhaled anaesthetics and intravenous propofol found significantly higher emissions for inhaled anaesthetics, with desflurane leading by a large margin. Lowering fresh gas flows amplifies the environmental impact of inhaled anaesthetics, particularly desflurane. Combining nitrous oxide with volatile anaesthetics increases emissions further. Waste disposal emissions dominate the environmental impact of inhaled anaesthetics, while propofol's emissions stem mostly from manufacturing and energy use, suggesting opportunities for pollution mitigation.

Strategies for Minimising Environmental Impact

To minimise environmental impact, strategies include avoiding desflurane and nitrous oxide unless clinically necessary. Total intravenous anaesthesia or regional anaesthesia should be considered when appropriate to eliminate inhaled anaesthetic pollution. When using inhaled anaesthetics, minimise fresh gas flows, especially during induction. While the FDA recommends specific fresh gas flow rates for sevoflurane, global adherence varies, and renal injury risk from Compound A is not well-established. Sevoflurane is generally considered safe at low fresh gas flows, especially with low or no sodium hydroxide in CO2 absorbents. The ASA supports the use of low fresh gas flows with sevoflurane based on current scientific evidence.

Mitigation Methods for Scavenged Waste Anaesthetic Gases

Methods to mitigate emissions from scavenged waste anaesthetic gases include volatile gas capture and nitrous oxide destruction. Emerging technologies directly adsorb or condense volatiles for potential reuse, but regulatory approval and transportation/storage challenges hinder widespread implementation. Nitrous oxide destruction is viable but not commercially practical due to its low cost and boiling point. Photochemical destruction technologies, used in Scandinavia, offer promise but are not widely available. Efficiency of waste gas treatment varies, with desflurane extraction estimated at 25%. However, un-scavenged gases from practices like inhaled inductions pose challenges. Further peer-reviewed assessments and life-cycle analyses are needed for these technologies. Prioritising interventions like avoiding impactful anaesthetics and minimising fresh gas flows is crucial before considering waste treatment technologies.

Recent reports from health systems in the U.K., New Zealand, and the U.S. reveal significant N2O losses, up to 77-95%, due to leaks in central pipeline systems. This has prompted many facilities to switch to portable tanks, advocated by initiatives like the Nitrous Oxide Project from the University of Edinburgh and supported by the Association of Anaesthetists in the U.K. Additional mitigation strategies include systematic closure of portable tanks between uses or eliminating N2O from the formulary altogether.

Source: **American Society of Anaesthesiologists**

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