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Environmentally Sustainable Anesthesia to Minimize Risks from Climate Change: a Societal Imperative or too Lofty a Goal?

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Abstract

Purpose of Review This review illustrates how anesthesia contributes to the carbon footprint. It gives practical reasons why anesthesiologists must understand and participate in sustainable anesthesia.

Recent Findings Climate change, with the increasing frequency of natural disasters that have negatively impacted health, has received increasing attention within healthcare systems and anesthesia practices. Education on how to green the operating room (reduce, recycle, reuse, rethink, research) is imperative for all anesthesiologists in order for them to implement these actions. The benefit of single-use disposable equipment such as laryngoscopes needs to be assessed thoroughly using life cycle methodology.

Summary Climate change is a global problem. Anesthesia contributes significantly to greenhouse emissions. Anesthesiologists must be educated on ways to mitigate this contribution and need tools that they can use to start reducing carbon emissions.

Keywords Climate change · Perioperative sustainability · Greening the operating room · Greenhouse gas · Life cycle assessment

Introduction

Climate change remains a dominant concern in modern times, affecting the environment and all aspects of life, healthcare included. In the USA, the healthcare sector accounts for 8.5% of national greenhouse gas emissions; globally, this sector represents 4.5% of total emissions [1]. Diving deeper into these statistics, hospital-based services contribute 36% to carbon emissions within the healthcare system, followed by medical and clinical practices at 12% and pharmaceutical provisions at 10% [2]. If the healthcare industry was counted as its own country, it would rank fifth globally in carbon emissions [3]. The negative repercussions on health caused by climate change are at odds with the foundational mission of healthcare; healthcare professionals today must strive to provide high-quality care in the context of being environmentally responsible.

The Global Warming Potential (GWP) is a measure that assesses a greenhouse gas's ability to trap heat in the atmosphere in comparison to carbon dioxide (CO2) over a specific duration. It aids in comprehending how various gases contribute to global warming. A higher GWP indicates that a particular gas has a greater warming effect on the Earth compared to CO2 over the chosen time frame. Typically, GWPs are calculated over a 100-year period [4, 5].

The Kyoto Protocol [6, 7], a landmark agreement in addressing climate change, highlights the consequences of burning fossil fuels. This process primarily releases carbon dioxide, along with other powerful greenhouse gases like methane and nitrous oxide [8, 9]. Even in lesser amounts, these gases may have a stronger impact on the climate compared to carbon dioxide. Human actions like deforestation, expanding urban areas, and waste emissions continue to hinder the Earth's inherent ability to absorb carbon, thus magnifying climate change consequences [10].

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Given these concerning trends, the use of volatile anesthetic gases in modern anesthesiology practice emerges as a double-edged sword. Anesthesia care is indispensable in modern medicine [11], ensuring unconsciousness, pain management, patient safety, and well-being during surgical procedures. However, current evidence has revealed concerning environmental implications involving specific aspects of anesthesia care that may contradict the broader aim of sustainability. This raises a critical question: can we reconcile environmentally responsible anesthesia practices with the increasing demands imposed on anesthesiology by modern medical and surgical care?

This review embarks on an in-depth exploration to: evaluate the potential environmental impact of anesthesia practices; delve into sustainable technologies; consider the economic ramifications; and examine ethical and societal perspectives. We aim to assess the feasibility of implementing sustainable anesthesia practices within current medical frameworks, acknowledging the associated challenges and opportunities. Ultimately, our aspiration is to contribute to a broader discourse that transcends the confines of the operating room and engages healthcare professionals, policymakers, patients, and the global community.

Volatile Anesthetic Agents

Greenhouse gases intensify global warming by capturing infrared radiation and elevating the Earth's average surface temperature. Operating rooms have inadvertently become sources of these emissions using potent volatile anesthetic agents such as desflurane. Even during routine clinical care, unexpected environmental contamination can occur due to patient exhalation of unmetabolized anesthetics and accidental releases from anesthesia equipment; these examples may seem minor compared to other industries like energy, but the cumulative environmental impact may be considerable on a global level [12, 13].

The use of volatile anesthetics accounts for 5% of greenhouse gas emissions from hospitals and other acute care health systems but represents a striking 50% of greenhouse gas emissions from surgery centers in industrialized nations [14]. The hospital and surgery centers anticipated growth rate from 2015 to 2024 is 4.0%, which, when considered in terms of daily use, is akin to driving over 1000 km each day [14].

The Global Warming Potential (GWP 100) is a critical metric used to compare the relative impact of different greenhouse gases on Earth's climate. It reflects their ability to trap heat over a 100-year period compared to carbon dioxide (CO2). Volatile halogenated ethers like desflurane, sevoflurane, and isoflurane are significant contributors to the greenhouse effect due to their complex molecular structures that capture and retain heat [15].

Desflurane is particularly potent, with a GWP 100 of 2540, indicating it has 2540 times the impact of CO2. It accounts for a substantial proportion—2.5 million metric tons—of the total 3 million metric tons of anesthetic gases released into the atmosphere each year. Given that a metric ton is equivalent to 1000 kg, this figure underscores the considerable scale of emissions that healthcare professionals must acknowledge and address [16].

While sevoflurane and isoflurane have lower GWPs, their environmental implications remain significant due to their usage and resulting emissions. Another anesthetic gas, nitrous oxide, is widely used across various medical settings, including hospitals, surgery centers, dental offices, and labor and delivery units. It has a GWP 100 of 298, making it 298 times more effective at warming the atmosphere than CO2, and it persists for 114 years, prolonging its environmental footprint [17•].

Furthermore, the flow rate plays a pivotal role in influencing both clinical and environmental outcomes. Modifying clinical practices to lower gas flow rates can substantially reduce the ecological footprint by decreasing anesthetic emissions, in line with the broader sustainability goals in healthcare. Nevertheless, it is essential to strike a balance between the advantages and potential risks of this adjustment. While modern carbon dioxide absorbents effectively minimize the risk of carbon monoxide formation, excessively low flow rates may result in higher production of compound A and carbon monoxide [18, 19].

Waste Anesthetic Gas Scavenging

Waste anesthetic gas scavenging systems are indispensable in contemporary anesthesia practice, serving environmental and occupational health roles. These systems are meticulously designed to capture excess anesthetic gases that would otherwise leak into operating rooms and other procedural spaces. While their primary function is to protect healthcare workers from exposure to trace amounts of these gases, which can have deleterious health effects, especially with chronic exposure, there is also an important environmental consideration [20, 21•].

When captured by scavenging systems, these gases do not simply vanish; they are typically vented to the outside atmosphere. While this diversion reduces indoor exposure for healthcare workers, it does not eliminate the environmental challenge. The released gases, especially halogenated agents, still produce greenhouse effects. Some advanced scavenging systems incorporate technologies to absorb, neutralize, or recycle these agents, but a universal solution remains elusive. As such, while scavenging systems may mitigate occupational hazards, the broader environmental impact of anesthetic gas release necessitates continued research and innovation in waste gas management [22].

Total Intravenous Anesthesia (TIVA) and the Environment

Total intravenous anesthesia (TIVA) and regional anesthesia are generally thought to have a lower environmental impact than volatile-based methods throughout their lifecycle, from production to disposal. However, the elevated costs of TIVA may hinder its adoption in resource-limited environments [17•].

The production and supply chain of intravenous anesthetic agents significantly contributes to carbon emissions in healthcare due to their manufacturing, packaging, transportation, and delivery processes [23, 24]. Wastage of anesthetic drugs is of significant concern. Over half of drugs prepared for clinical care are unused, with propofol constituting up to 45% of this waste and deemed to be the most environmentally detrimental [25].

The discharge of intravenous anesthetics from hospitals, either as waste or excretion, poses a considerable ecological threat. Thus, striking a balance between global climate issues and local water pollution becomes imperative.Propofol exemplifies this issue. Accumulation within animal tissues and persistence in aquatic ecosystems present immediate and long-term challenges. Addressing such contamination can be complex and costly [26, 27].

Increased TIVA usage may further strain aquatic ecosystems, potentially affecting human health. To fully understand the environmental impact of anesthetics, research is vital [25]. Medical professionals are responsible for making environmentally conscious choices regarding medications, supplies, and practices. While the environmental footprint of propofol is concerning based on available data, a life cycle assessment reveals that its impact is significantly less than desflurane or nitrous oxide [28].

Greening the Operating Room Through the 5Rs

As environmental awareness grows, the focus has turned to "greening" the core of healthcare: the operating room. Due to anesthetic gases, energy-intensive equipment, and waste, operating rooms significantly contribute to this footprint [29, 30]. Hospitals in developed nations generate 1% of solid waste and 2.1% of greenhouse gas emissions annually [4].

Transportation and incineration of waste yield significant greenhouse gas emissions, with 1 kg of clinical waste producing 3 kg of carbon dioxide. Within the operating room, anesthesiologists are responsible for up to 25% of the waste generated [31].

Several factors exacerbate operating room waste, including the prevalent use of single-use plastics, unwarranted opening of sterile packs, excessively packed supply kits, incorrect waste categorization, and insufficient recycling practices. It is noteworthy that the majority of operating room waste is comprised of paper (40%) and plastics (58%) [32].

To lessen the environmental footprint, the 5Rs rule—Reduce, Reuse, Recycle, Rethink, Research—has been championed in the operating room [33, 34•].

Reduce

Surgical procedures, employing supplies such as disposable gowns, gloves, and single-use surgical tools, produce substantial waste. This waste presents environmental and economic challenges. Hospitals are now adopting reprocessing programs for specific medical devices. There is a growing emphasis on using recyclable materials and refining waste segregation. Sterilizable surgical drapes and gowns are also returning to favor over single-use items [35–38].

Reuse

Transitioning back to items like reusable caregiver garments can help in significantly reducing the environmental footprint. There is a resurgence in using tools such as ventilation masks and laryngeal mask airways in anesthesia. Recognizing that every operating room item—from surgical instruments to patient drapes—carries an environmental cost, there has been a shift towards embracing sustainable materials, forming collaborations with eco-conscious suppliers, and exploring biodegradable alternatives [39, 40].

Recycle

Recycling is pivotal in the operating room. Its benefits are fully realized when the environmental costs of collection and reprocessing are counteracted. Items like paper, cardboard, batteries, plastics, metals, and specialized tools like laryngoscope blades can be recycled. Medical glass recycling, distinct from household glass recycling, is sparse but warrants further consideration and potential expansion [41–45].

Rethink

Rethinking involves reevaluating practices, advocating for sustainable purchasing, and optimizing pre-packaged kits. Enhanced education and staff involvement can decrease waste by 6.5% monthly [46]. Telemedicine offers a way to decrease the carbon footprint through fewer in-person visits and the associated commutes, even accounting for the emissions from electronic devices. Furthermore, environmental and waste considerations are vital when developing new healthcare systems, including facility planning. Operating rooms are major energy consumers, with medical equipment, heating and cooling systems, and lighting significantly contributing. Hospitals are transitioning to energy-efficient lighting, utilizing light-emitting diode (LED) lights, and moving to alternative energy sources, energy-efficient medical devices, and optimized heating and cooling systems.

Research

Limited data on the environmental impact of various healthcare systems, operating room structures, and new medical technologies are currently available. Research should further explore the creation of eco-friendly devices, such as biodegradable trays or drapes.

Life Cycle Assessment

The life cycle assessment is a pivotal methodological approach that transcends merely evading single-use equipment. This assessment can be facilitated using software tools, like SimaPro (Amersfoort, Netherlands), to gauge environmental ramifications. Studies indicate a safety assurance when utilizing reusable equipment [47–49].

Research indicates that reusable medical equipment is safe to use. In fact, practices like washing hands properly, keeping patients warm, and managing their body fluids might play a bigger role in preventing infections after surgery than using disposable items once and throwing them away [50]. The study by Keil et al. points out that when hospitals switch to tools that can be cleaned and reused, particularly those that are invasive (used inside the body), it can be better for the environment. However, this switch could lead to using more water, which might become a problem as climate change makes water less available [51].

Interestingly, water use may increase. This may create a potential issue with climate change pressure on water supply. The authors advocate for a Life Cycle Assessment transparency checklist, which is mainly based on US/European standards. Carbon emission from reusable equipment depends primarily on the local power grid. For instance, using reusable equipment with a US or European power grid can significantly reduce carbon emissions by almost 50%. However, in countries like Australia, the use of reusable equipment may actually increase carbon emissions due to their reliance on coal-based energy [52].

The Challenge of Changing Practices

The challenge of reducing the carbon footprint in healthcare is multifaceted. One major aspect of this challenge is the lack of standardized and transparent reporting of greenhouse gas emissions [53]. Next is the absence of accepted benchmarks and enforcement mechanisms. At present, the Veterans Affairs and National Health Services are viewed as the gold standard models [54]. However, these are government-run entities with rigorous and publicly available environmental standards established. Financial incentives, in the form of tax credits, are offered to nonprofits in the US through the Inflation Reduction Act. The Cleveland Clinic effectively combined energy and cost savings with their green revolving fund initiative. This project started with small investments in LED lights and thermostat adjustments and then, over the past decade, grew into a $35 million investment that has resulted in $100 million in savings [55].

Conclusion

Global climate change presents a substantial challenge for the healthcare industry, requiring the active involvement of all stakeholders for an effective response. The need for improved education and standardization in measuring the impact of individual processes is evident. Addressing this concern goes beyond the singular roles of anesthesiologists or other staff in the perioperative domain. Hospitals, medical and nursing societies, alongside local, state, and federal governments, must be proactive participants. Economic factors and patient safety need to be balanced against environmental ramifications. The operating room stands out as a primary area for enacting positive change, and greening the operating room requires a holistic approach. Beyond selecting anesthetic agents, the broader strategy encompasses energy consumption, waste management, material sourcing, and medical care. Striking a balance between patient safety, cost-effectiveness, and environmental responsibility is crucial. The adoption of sustainable practices is not too lofty a goal; it is both practical and achievable with benefits to patients and the planet.

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Declarations

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