Environmental Footprint of Anesthesia

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EDITORIAL

Environmental Footprint of Anesthesia: More than Inhaled Anesthetics!

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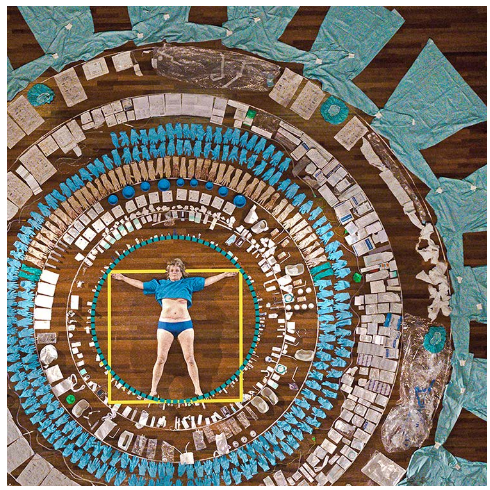

"[What is] the carbon footprint of general, regional, and combined anesthesia?"

Climate change is an increasingly apparent global reality. According to the new United Nations (New York, New York) Intergovernmental Panel on Climate Change report, published on August 9, 2021, the scientific consensus is that there is still time to act, but immediate action is required and "demands strong and sustained reduction in carbon dioxide and other greenhouse gases."[1] Although fossil fuel burning is still the major source of greenhouse gas emissions, each sector can take action to reduce its share of emissions, including indirect emissions that occur in the supply chain. A series of studies over the past half decade have revealed that the global environmental footprint of health care is significant[2]; its contribution to total global greenhouse gas emissions (in carbon dioxide equivalents) is nearly 5%.[2,3] These studies make it clear that clinicians and health care professionals have a vital role to play in tackling climate change, deemed by the World Health Organization (Geneva, Switzerland) as "the greatest threat to global health in the 21st century."

In recent years, various (inter)national anesthesia societies have launched initiatives to minimize the environmental impact of our profession, largely focusing on the management of waste anesthetic gases.[4] Along with nitrous oxide, these halogenated ethers are themselves potent greenhouse gases with significant global warming potentials. Taken together, their direct emissions are responsible for an estimated 3% of the climate footprint of national healthcare systems in industrialized countries and can account for more than 50% of greenhouse gas emissions from the perioperative chain.[5] Recommendations include the utilization of low fresh gas flows, the avoidance of high-impact inhaled anesthetics (desflurane, nitrous oxide), the consideration of intravenous and regional techniques, and the investment in waste anesthetic gases trapping or destroying technology.[6]

While the greatest emphasis to date in the anesthesia literature has understandably been on the carbon footprint of inhaled anesthetics,[4] they are just one environmental consideration within the complex system of products and services that make up anesthesia practice. If we are to make evidence-based decisions on how to deliver perioperative care in the most sustainable manner, we need a holistic picture of what matters and what does not. "Life cycle" studies can provide this perspective and have been published on a range of products and procedures, often making comparisons among options. But as we all know, every case is unique. What has been mostly lacking to date is research that analyzes the environmental impacts of health care *across* multiple cases so that we can understand variations, quantify uncertainty, and test whether a recommendation is generally applicable or more case dependent.[7]

In this issue of Anesthesiology, McGain *et al.* provide a detailed comparison of the carbon footprint of general, regional, and combined anesthesia for total knee replacement in Australia, using a small cohort of 10 patients per group.[8] Aiming for a complete picture, they collected input data on anesthetic consumables, gases and drugs, and electricity for patient warming and the anesthesia machine. (In the general anesthesia group, sevoflurane or propofol was used, but no desflurane or nitrous oxide.) The investigators then conducted a Life Cycle Assessment to convert all of these input data into estimates of carbon footprint, with

Image: Maria Koijck/Eva Glasbeek.

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the hypothesis that spinal anesthesia would have the lowest impacts. They instead observed that the mean value was similar for general, spinal, and combination approaches, with significant overlap among the CIs. Within each group, there were large variations in results stemming from case-by-case differences in how anesthesia was administered. Examining the relative contributions of each input reveals some important trade-offs and offers lessons for our own practices.

First considering the anesthetic agents, sevoflurane was an important contributor but did not dominate results. For general anesthesia, sevoflurane contributed an average of 4.7 kg carbon dioxide equivalents (range, 2.7 to 8.6 kg carbon dioxide equivalents) or 35% of the total carbon footprint. (It should be noted that the contribution of inhalational gases would certainly have been higher if desflurane or nitrous oxide were used in the included cases.) Patients receiving total intravenous anesthesia were at the low end of the range of general anesthesia results. In the combined group, the contribution of sevoflurane was only 19% on average. The spinal group of course had zero contribution from inhaled anesthetics, but this relative carbon savings was more than offset (on average) by a large increase in emissions from washing and sterilization of surgical items (4.5 kg carbon dioxide equivalents) and the production of oxygen (2.8 kg carbon dioxide equivalents) for high-flow nasal cannula during locoregional anesthesia.

Other considerations were more consistent across groups. Single-use items have received much attention and contributed a substantial 25% of the total carbon footprint, with slightly higher results for the combined group. Perhaps surprisingly, the next largest contributor was electricity for the patient warmer at approximately 20%, while pharmaceuticals were nearly 10% of the total across groups.

What does this mean for clinical practice? Because of the large variations in results for each of the groups, the investigators were able to note practices that led to lower impacts. Some were specific to the anesthetic technique applied, such as using low-flow anesthesia or total intravenous anesthesia in general anesthesia or reducing oxygen flows when possible for spinal anesthesia. Other recommendations cut across all techniques, such as reducing single-use plastics or improving energy efficiency of patient warmers. The shift from single-use to reusable items has been a focus of multiple studies with results showing environmental and economic benefits in nearly every case.[9,10] Taking multiple actions to reduce emissions was found to be more beneficial than simply shifting to a different anesthetic technique.

Although the study expanded the boundaries of what is typically included in a clinical care Life Cycle Assessment, it is impossible to consider every possible input and permutation. Of particular note is the exclusion of heating, ventilation, and air conditioning systems and lighting systems, which are often a target of healthcare sustainability programs. Another important area is waste generation. Surgical and anesthesia procedures using mostly single-use items produce a significant amount of "medical trash," as illustrated in figure 1 by the Dutch artist Maria Koijck, who created an artwork using all disposable items from her own breast reconstruction surgery and anesthesia. The analysis from McGain *et al.*[8] assumed that nonpharmaceutical waste is either recycled or landfilled, with little consequence for the results. If instead this waste were incinerated (and its carbon liberated), then its contribution to emissions would be much higher. Also, it is important to remember that climate change is just one (albeit critical) environmental challenge we are facing. Air pollution, water pollution, depletion of finite resources, and numerous other impacts can also be modeled using Life Cycle Assessments.

The study by McGain *et al.*[8] is a small, single-center, prospective, nonrandomized, observational, unblinded study with various limitations that make comparison between anesthetic groups and between countries uncertain. The authors included only 10 patients per group ("convenience sample"), and the study is clearly underpowered to compare the footprint of various anesthetic techniques, as cautiously stated by the authors. As such, this study doesn't offer a definitive answer about which anesthetic method is the most detrimental to the climate, and it should not be misquoted to favor or reject the use of a specific anesthetic technique. What this study does offer is an interesting example of how clinical or cohort studies can be used for sustainability analysis (even with low numbers of included patients). As such, it shows a next step in a progression of research that has been slowly revealing different aspects of sustainability in clinical care.

Some aspects of a carbon footprint are location-dependent; for example, the emissions associated with electricity use depend on how electricity is generated locally. The Life Cycle Assessment is flexible in being able to test different assumptions about where different products originate or where certain processes take place, and the authors use this flexibility well to estimate how the results would change for clinical settings in Europe, the United Kingdom, or the United States. Those aspects of anesthesia that are electricity-intensive, such as steam sterilization,

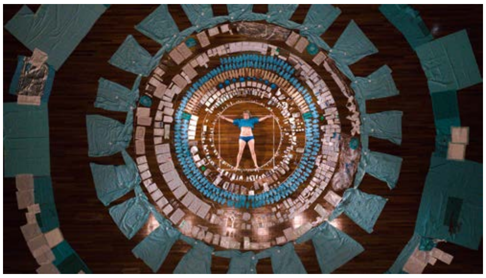

Fig. 1. Dutch spatial artist Maria Koijck created an artwork with trash from her own surgery and anesthesia (photo: Maria Koijck and Eva Glasbeek, published with permission).

oxygen compression, and patient warming, had one fourth the emissions in Europe/United Kingdom than in Australia because of differences in the carbon intensities of electricity between the two regions. Therefore, a valuable lesson that the authors highlight is that recommendations for sustainable clinical care must consider local conditions. We cannot assume *a priori* that actions to reduce emissions in one clinical setting or country will have exactly the same effect somewhere else. Future studies, carbon accounting tools, and reporting frameworks that are developed for anesthesia and health care generally should ideally be flexible enough that clinicians can extract recommendations that are accurate for their own institutions, wherever they are.

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Competing Interests

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