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Impact of Anesthesia on Climate Change

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Abstract
The phenomenal growth of the healthcare sector has created an industry responsible for a significant part of global environmental pollution. Reduction of the environmental footprint from energy consumption can be achieved by decarbonizing our economy in three ways (‘the trias energetica’), i.e., minimizing energy consumption, generating sustainable energy, and using fossil fuels efficiently. We confront a state of planetary emergency because GHG emissions and global warming/climate change contribute to one-quarter of all deaths worldwide. The World Health Organization considers climate change as the greatest threat to global health.
Anaesthesia providers must minimize the environmental impact of their clinical practice and anesthesiologists need to be concerned about reducing their carbon footprint. They must address the 3% carbon footprint from direct emissions of anesthetic gases, 25% from single-use consumables, 20% from energy generation, and 10% from upstream activities from pharmaceutical suppliers, and downstream distribution activities like supply chain management and waste processing.
The 5 Rs mantra of Reduce, Reuse, Recycle, Rethink, and Research will reduce the environmental impact of anesthesiology, which will also reduce costs. These must be overseen by a lead individual for sustainability in the department of anaesthesia who will use measurement tools to determine their department's annual carbon footprint and also prioritise the teaching of environmentally sustainable anaesthetic techniques.

Keywords: Anesthesia, climate, global warming, greenhouse gases, CO2

Introduction
Anaesthetic practice has impacted climate change and contributed to a global problem that requires global solutions. Climate change is the biggest threat to global health in the 21st century and healthcare systems must take immediate action to ensure a strong and sustained reduction in emissions of greenhouse gases to save the earth from a catastrophe.
The UN Secretary-General António Guterres, in his message on Earth Day 2024, stated, “We depend on nature for the food we eat, the air we breathe, and the water we drink, but we have brought chaos to the natural world: poisoning our planet with pollution, wiping out species and ecosystems with abandon, and destabilising our climate with greenhouse gas emissions.Together, we must restore harmony with nature and protect ourselves from harm – creating jobs, reducing poverty and driving sustainable development as we do so”.

The Components of Climate Change
The downward moving high frequency, short-wavelength solar radiation maintains the Earth’s average surface temperature. Measured as watts per square metre, this (solar constant) measures 1366 watts/sq m annually. Since 50% of the earth's surface receives solar radiation at any one point in time, the average surface input is estimated at 342 watts/sq m annually. Out of every 100 units of incoming solar radiation, 30 units are reflected into space by clouds, ice cover and reflective regions as outgoing long wave, low frequency infrared (IR) radiation. To maintain thermodynamic equilibrium, the balance of 70 units must be radiated into space. The Earth ‘s atmosphere is more transparent to solar when compared to thermal radiation, and the difference between incoming and outgoing radiation is called radiative forcing. (Fig 1)

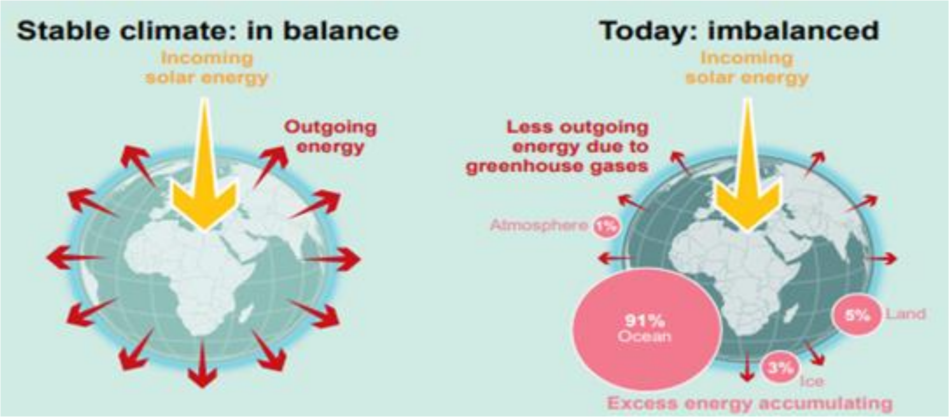

Fig 1: The Earth's Evolving Energy Budget.

99% of the Earth's dry atmosphere (excluding water vapour) consists of 78% nitrogen (N2), 21% oxygen (O2) and 0.9% argon (Ar). N2 and O2 molecules contain two atoms of the same element. Symmetric distribution of their electrical charges renders them unaffected by infrared thermal radiation, except for a very minimal effect from collision-induced absorption. Argon (Ar), is monatomic and utterly transparent to thermal radiation. The three main greenhouse ozone-depleting gases are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). They account for less than 0.1% of the Earth's atmosphere in concentrations of 0.04%, 0.000330% and 0.00018%, respectively. The current atmospheric concentration of CO2 is 420 ppm, and an average adult releases 0.66 kg of CO2 daily. Seven billion people will exhale around 1.7 gigatons (billion tons) of CO2 into the atmosphere annually. Burning of fossil fuels releases 41 gigatons annually. CO2 soaks up infrared energy and radiates half of it to Earth as heat. Methane, with an atmospheric concentration of 2000 parts per billion, has a global warming potential 80 times greater than CO2.

GHG molecules contain atoms of different elements, and there is an asymmetry in the distribution of their electrical charges. They are infrared active and interact with electromagnetic radiation to absorb and reflect long wavelength infrared rays to the Earth's surface. Termed the "greenhouse effect," this is similar to heat-trapping by the glass walls of a greenhouse. Without GHG, the Earth's surface air temperature would be 33C colder, in the range of -18 °C (-0.4°F), and too cold to sustain life.

Increased concentrations of GHG and aerosol emissions by human activity warms the Earth's atmosphere considerably. This results in a net increase in surface radiation. Since 1750, at the beginning of the industrial revolution, CO2 levels have climbed by over 50%, at a rate of 1.4 to 2.0 ppm/year, from 280 ppm to 420 ppm. Human activity (anthropogenic emission) accounts for 3% of total CO2 emissions, amounting to 7 billion tons annually, of which only 2-3 billion tons are offset by natural sinks. The carbon cycle takes thousands of years to absorb CO2 from the atmosphere fully. The excess CO2 is responsible for 75% of global warming. By 2050, CO2 concentrations will reach 560 ppm resulting in a surface warming of 2 to 5C above that in the preindustrial era. Methane levels have increased by 150%. (1)

The atmospheric lifetime of a greenhouse determines its ability to absorb thermal radiation. Water vapor is responsible for half of the greenhouse effect, but this is unaffected by human activity and, thereby, not a driver of climate change. CO2 lasts 5 years, methane lasts 10 to 12 years, while N2O retains its environmental effect for 114 years (Fig 2).

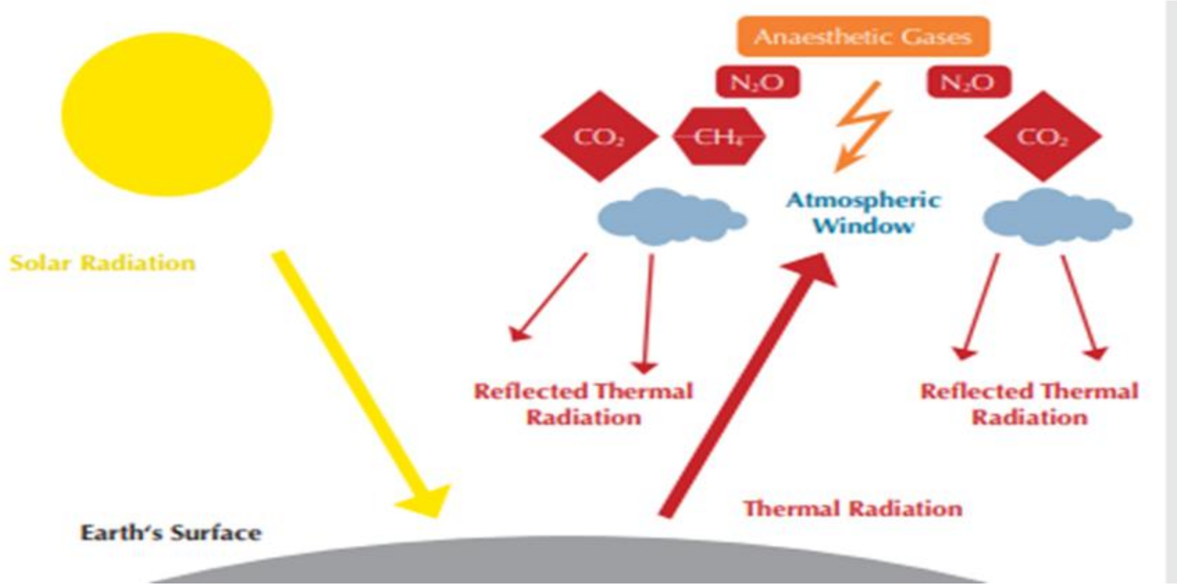

Fig 2: The Atmospheric Window and Effect of GHG.

Greenhouse gases are estimated in CO_2 equivalents (CO_2e). This refers to the number of metric tons of CO_2 with a similar global warming potential (GWP) as one metric ton of a different GHG. Carbon dioxide has a GWP of 1, making it the reference gas for all other GHGs and reflects the amount of heat it will trap over the next 100 years. For methane, GWP is 28 CO_2e; for nitrous oxide, it is 273CO_2e, and for hydrofluorocarbons (CFC), it is 14,600 CO_2e. (2)
The stratosphere is a mass of protective gases surrounding our planet. The ozone in this layer constitutes 0.00006 percent of Earth's atmosphere. There are only three molecules of ozone for every ten million molecules of air. Ozone absorbs 98% of the potentially harmful ultraviolet rays and acts as a protective shield or a sponge. Ozone molecules have three oxygen atoms. These are constantly undergoing destruction and reformation. CFCs prevent this, resulting in thinning of the ozone layer. They do not punch holes, as commonly believed. The ozone layer is the thinnest over the poles. (3)

Impact of Global Warming

GHG emissions and global warming/climate change have resulted in state of planetary emergency, contributing to an additional 250,000 deaths per year. The World Health Organisation describes climate change as the greatest threat to global health.
Humanity needs to stop acting like Earth's delinquent child by ignoring the scale of the problem of global warming. The 2015 Paris agreement treaty with 195 signatory nations, has pledged to limit global warming to 1.5C above the preindustrial era. This mandates significant reduction of GHG by 2030, and to net zero by 2050. Any rise in the Earth's surface temperature above 3.2°C will be catastrophic, reaching a tipping point and having wide-ranging and destructive impacts like thawing of the permafrost, forest dieback and El Nino. All of these will render our mother Earth uninhabitable, like our nearest planet Venus. (4, 5, 6)

Definitions

Global warming is the long-term trend of increasing average global temperatures of near surface air on our planet.
Climate change is a change in global or regional climate patterns, particularly apparent from the mid- to late 20th century onwards, attributed to the increased levels of atmospheric carbon dioxide from fossil fuel use.
Carbon footprint is the total GHG emissions caused directly and indirectly by a person, organization, event, or product.
Greenhouse effect is the warming of Earth's surface and lower atmosphere caused by water vapour, carbon dioxide, methane, nitrous oxide and other GHG. (7)

Healthcare and Climate Change

The healthcare sector is responsible for 5-10% of all GHG emissions. Healthcare is a paradox, responding to the disease burden created by climate change and aggravating the problem simultaneously. The main contributing factors are energy-intense departments like intensive care units, operating suits and prehospital emergency services. Anaesthetic gas and vapour emissions compound the problem further. Healthcare must transform into a sustainable industry to minimize its impact on climate change.

The operating room (OR) carbon footprint can be categorized into three major scopes.

1. Scope 1 concerns direct emissions, in the form of anaesthetic gases.
2. Scope 2 in the form of indirect emissions from energy generation.
3. Scope 3 in the form of all indirect emissions from upstream and downstream activities (i.e. supply chain and waste processing).

Anesthesia and Global Warming

Anesthesiologists need to be concerned about reducing their carbon footprint. Two-thirds of healthcare's carbon footprint is from procuring pharmaceuticals, equipment, and instruments, and only 5% is from emission of anaesthetic gases and vapours. Of these, clinical sources of N_2O account for 1% of the total human contribution into the atmosphere, accounting for 0.1% of the total global warming effect. Human activities and agriculture are the major N_2O polluters, causing an increase in levels from 316.3 PPM to 337.61 parts per million (PPM) over the past 25 years. This is expected to increase by 35–60% shortly due to poor manure management and increased application of chemical fertilizers. N_2O is minimally metabolized in humans. The gas has a GWP that is 298 times more than an equivalent volume of CO_2, making it a super pollutant. N_2O also damages the ozone layer, where it converts into nitrogen oxides in the presence of sunlight and oxygen. Maximum anaesthetic emission of N_2O occurs when the gas is used for inhalational analgesia, such as Entonox, during labour and also as a primary refrigerant for cryosurgery. (8,9,10,11)
The annual consumption of anaesthetic gases worldwide is estimated at 12.5 million cylinders.
Voilatile anaesthetic vapours amount to a CO_2 equivalent of 5 million tons of CO_2 annually of which 70 % is from sevoflurane, 20 % from desflurane and 10 % from isoflurane and accounting for a share of 0.01 % of global CO_2 emissions.
All volatile anesthetics are halogenated chlorofluorocarbons (halothane, enflurane, isoflurane) or fluorinated hydrocarbons (sevoflurane and desflurane). Their vapours absorb IR within the range of 7–10 µm. Desflurane, a fluorinated methyl ethyl ether, has 26 times the GWP of sevoflurane and 13 times that of isoflurane. This translates to an emission of 190kg CO_2/250ml for isoflurane, 49kg/250 ml for sevoflurane and 886 kg CO_2/240 ml for desflurane. The tropospheric lifetime of these agents are 6.6 years for halothane, 5.9 years for isoflurane, 4.0 years for sevoflurane and 21.4 years for desflurane. Metabolites of volatile anesthetics have ozone depleting property (ODP) except for sevoflurane and desflurane that are devoid of chlorine. Isoflurane has an ODP of 0.01 and halothane has an ODP of 1.6 due to their bromine content. Desflurane or sevoflurane use from a modern anaesthetic machine for a duration of one hour is equivalent to driving a car for 230- or 30-miles car travel respectively. Desflurane alone, accounts for 80% of total volatile emissions. (12,13,14,15)

Mitigation of Adverse Effects

If N_2O use as a carrier gas is to be minimized, ultra-low flow technique using fresh gas flows of < 0.5 litre min^{-1} and replacing nitrous oxide with air is recommended. Leaks have to be curtailed. Masks must be checked for a good fit, with routine pressure leak checks for circuits and valves. Do not underinflate endotracheal tube cuffs, minimize circuit flushing and avoid spillage when refilling vaporizers. N2O use as a refrigerant in cryosurgery must be phased out. Excidio Technology using selective catalytic reduction (SCR), to convert nitrous oxide to oxygen and nitrogen is available for small anaesthesia facilities. Existing N2O pipelines will have to be decommissioned and new installations substituted with portable tanks that remain closed between use. The elemental anaesthetic agent Xenon does not support the greenhouse effect, but its costs are prohibitively high. Advanced anaesthesia machines with recycling equipment would be required for xenon to replace N2O, since financial implications remain a major barrier to sustainable practice changes.Well-maintained circle breathing circuits should always be preferred to semi-open or open breathing circuits. (16,17,18,19,20,21)

Wherever N2O or a volatile anesthetic is administered, an active waste anesthetic gas disposal (WAGD) systems/scavenger system must be used to prevent waste gas accumulation. The institution must organize and document a program of periodical maintenance and checking of all anesthetic equipment, including the scavenging system. Modern ventilation systems expel vitiated gases to the outside atmosphere to avoid theatre pollution, whereas the latest scavenging systems allow for the collection, capture, reuse, or destruction of gases. (22)

Activated charcoal can effectively adsorb volatile anaesthetics. However, the saturated charcoal will quickly desorb and release agents into the environment. The Anesthetic Gas Reclamation system can serve up to 8 operating rooms, and it brings cost-effective, environmentally-sensible anaesthetic gas recycling. It's exhaust system is activated only when the patient exhales with traces of volatile and gaseous anaesthetic agents. This results in energy savings, as the vacuum pump operates for limited periods. Capture of unused anesthetics by the Deltasorb canister system is an alternative. The canisters are exchanged for volatile anesthetic recovery and recycled. Anesthesiologists must opt for the inhalational agent(s) with the lowest GWP and select other agents in specified pre-approved cases only. (23,24)

The Montreal protocol of 1987 is one of the rare treaties to achieve universal ratification and aims to phase out global chlorofluorocarbon use completely. The 2016 Kigali amendment targets hydrofluorocarbons. Anaesthetic vapours and gases are often excluded from their deliberations because of their medical necessity. While the damage caused by anaesthetic emissions has been comprehensively described, the barriers to sustainable practices in the field have been overlooked. (25,26)

Along with the personal preferences of individual anesthesiologists, the practice of anaesthesia is dictated by patient, surgical, and anaesthetic factors. There is no consensus with respect to the benefit and harm to patients and population from existing anaesthetic protocols. There are considerable practice variations on the use of hydrofluorocarbon and chlorofluorocarbon anesthetics, and there are many barriers to standardize their use. Agreement towards a unified approach towards the use of anaesthetic gases and volatiles presents problems, since the scope must involve everyone, everywhere.

The adoption of lean working practices in ORs must be encouraged. The 5 Rs of waste minimization (Reduce, Reuse, Recycle, Rethink and Research) have proven beneficial in reducing the carbon footprint of anaesthetic practice as well as in cost reduction. Each theatre produces approximately 2300 kg of waste annually, and only 10% is currently recycled. Joint purchasing of bulky or high-volume items will reduce transport emissions. Resuscitation decisions may be discussed with patients through living wills and advanced directives. This will ensure that resources are not used needlessly and vitiate the environment. With general anaesthesia (maintenance with sevoflurane or propofol), CO2 emissions are 14.9 kg CO2. For neuraxial anaesthesia it is 16.9 kg CO2 equivalent as the relative carbon savings is offset by emissions from washing and sterilization of surgical items (4.5 kg carbon dioxide equivalents) and oxygen administration (2.8 kg carbon dioxide equivalents) during the procedure. (27,28,29)

Intravenous anesthesia and regional anesthetic techniques preclude the use of volatile agents altogether. When supplemented with inhalational or intravenous anaesthesia, regional anaesthetic techniques have a ‘MAC sparing’ effect, reducing the consumption of volatile anaesthetics. However, degradation products such as phenol from propofol can accumulate in the food chain and syringe residue has to be discarded with sharps, to be destroyed in incinerators at 1000°C.(30)

Energy consumption can be reduced in three ways (‘the trias energetica’): minimizing energy consumption, sustainable energy generation and efficient use of fossil fuels.

The provision of compressed air is an energy-intensive process with high electricity consumption averaging 11,738 kWh. This corresponds to an annual emission of 5.7 tons CO2. Sustainable anaesthetic practice involves:

- Balancing the benefits and risks for all patients.
- Adopting lean working practices.
- Minimizing waste in the operating room.

Global warming and ozone depletion is significantly reduced with 40 reuse cycles of laryngeal mask airways (LMAs). Life-cycle analyses of operating room gowns and drapes indicate that reusable textiles consume significantly less energy, water, carbon, organic chemicals, and solid waste than single use materials. Costs, level of protection and comfort are similar. Anaesthetic room steel laryngoscope blades and other steel waste can be sterilized and recycled as scrap. (31,32,33,34)

Healthcare professionals in the operating room should primarily focus their attention on optimizing heating, ventilation, air conditioning (HVAC) and laminar airflow systems. They are responsible for up to 90–99% of the energy demand. Some of these high-end systems lack evidence of preventing surgical site infection and may be phased out. General measures such as light-emitting diode (LED) lighting, green energy procurement, hospital thermal isolation and photovoltaic panels can be adopted. (35,36)

Anesthesiologists, medical staff and patients must be encouraged to use low-carbon options (e.g. walking, cycling, mass transportation) when travelling to hospital. Preferred online attendance at meetings and conferences is desirable.

Conclusion

Present-day anesthesiologists must minimize these adverse effects through sustainable development and carbon taxation, with the goal of achieving net zero CO2 emissions latest by 2050.

Health systems should quantify emissions of inhaled anaesthetic gases, set reduction targets and timelines, and track progress. Tracking of mean gas flow rates per hour and intensity of anaesthetic emissions (kgCO2e/hour) can be assessed from electronic health records. A healthcare regulatory framework of standardised, mandatory reporting and accountability is critical to achieving the widespread engagement required to reduce GHG emissions. Anesthesiologists must take serious notice of the impact of their profession on the environment and integrate them into their daily work. In this way, we can make our contribution to a more sustainable health sector. (37,38,39)

References

1. Cassia R, Nocioni M, Correa-Aragunde N, Lamattina L. Climate Change and the Impact of Greenhouse Gasses: CO2 and NO, Friends and Foes of Plant Oxidative Stress. Front Plant Sci 2018;9:273.
2. Mikalai Filonchyk, Michael P. Peterson, Lifeng Zhang, Volha Hurynovich, Yi He. Greenhouse gases emissions and global climate change: Examining the influence of CO2, CH4, and N2O, Science of The Total Environment. Science Direct 2024;935: 173359. ISSN 0048-9697
3. Bais AF , Lucas RM , Bornman JF , Williamson CE et al. Environmental effects of ozone depletion, UV radiation and interactions with climate change: UNEP Environmental Effects Assessment Panel, update 2017. Photochem Photobiol Sci 2018;17(2):127-179
4. Erickson LE. Reducing greenhouse gas emissions and improving air quality: Two global challenges. Environ Prog Sustain Energy 2017;36(4):982-988
5. Rossati A. Global Warming and Its Health Impact. Int J Occup Environ Med. 2017;8(1):7-20.
6. McMichael AJ. Globalization, climate change and human health. NEJM 2013;368:1335-1343
7. Watts N, Amann M, Arnell N, et al.. The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. Lancet 2018; 392:2479–2514
8. Karliner J, Slotterback S, Boyd R, et al. Healthcare's climate footprint: how the health sector contributes to the global climate crisis and opportunities for action: healthcare without harm. A.R.U.P; 2019:48
9. Lineman M, Do Y, Kim JY, Joo GJ. Talking about Climate Change and Global Warming. PLoS One 2015;10(9):e0138996
10. Romanello M, McGushin A, Di Napoli C, et al. The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. Lancet 2021;398(10311):1619-1662.
11. Rocque RJ, Beaudoin C, Ndjaboue R, Cameron L, Poirier-Bergeron L, Poulin-Rheault RA, Fallon C, Tricco AC, Witteman HO. Health effects of climate change: an overview of systematic reviews. BMJ Open 2021;11(6):e046333
12. Slingo ME, Slingo JM. Climate impacts of anaesthesia. Br J Anaesth 2021 ;126(6):e195-e197
13. Sherman JD, Chesebro BB. Inhaled anaesthesia and analgesia contribute to climate change. BMJ 2022;377:o1301
14. Andersen MPS, Nielsen OJ, Wallington TJ, et al.. Assessing the impact on global climate from general anesthetic gases. Anesth Analg 2012; 114:1081–1085.
15. Ishizawa Y Special article: general anesthetic gases and the global environment.Anesth Analg 2011; 112: 213-217
16. Feldman JM. Managing fresh gas flow to reduce environmental contamination. Anesth Analg 2012;114:1093-101.
17. Ryan SM Nielsen CJ Global warming potential of inhaled anesthetics: application to clinical use.Anesth Analg 2010; 111: 92-98
18. Seglenieks R, Wong A, Pearson F, McGain F. Discrepancy between procurement and clinical use of nitrous oxide: waste not, want not. Br J Anaesth 2022;128:e32-4
19. Richardson MG, Lopez BM, Baysinger CL. Should nitrous oxide be used for laboring patients? Anesthesiol Clin2017;35:125-43.
20. Canto MI, Abrams JA, Künzli HT, et al. . Nitrous oxide cryotherapy for treatment of esophageal squamous cell neoplasia: initial multicenter international experience with a novel portable cryoballoon ablation system (with video). Gastrointest Endosc 2018;87:574-81.
21. Dingley J, Hughes LG. Xenon: a replacement for nitrous oxide. Curr Opin Anaesthesiol. 2000;13(4):443-7.
22. Barrick BS. WAG treatment and CO2 absorbers: new technologies for pollution and waste prevention. ASA Monitor2018;82:12-4
23. Birgenheier N, Stoker R, Westenskow D, Orr J. Activated charcoal effectively removes inhaled anesthetics from modern anesthesia machines. Anesth Analg 2011;112(6):1363-70
24. Wong, K., Wasowicz, M., Grewal, D. *et al.* Efficacy of a simple scavenging system for long-term critical care sedation using volatile agent-based anesthesia. Can J Anesth/J Can Anesth 2016; 63, 630–632.
25. Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer Twelfth edition 2018. United Nations Environment Programme
26. The Kigali Amendment to the Montreal Protocol: HFC Phasedown. 2016. UN Environment Programme
27. Cançado TOB, Cançado FB, Torres MLA. Lean Seis Sigma e anestesia [Lean Six Sigma and anesthesia]. Braz J Anesthesiol 2019;69(5):502-509
28. Rizan C, Steinbach I, Nicholson R, Lillywhite R, Reed M, Bhutta MF. The Carbon Footprint of Surgical Operations: A Systematic Review. Ann Surg 2020 ;272(6):986-995
29. McGain F, Sheridan N, Wickramarachchi K, Yates S, Chan B, McAlister S. . Carbon footprint of general, regional, and combined anesthesia for total knee replacements. Anesthesiology 2021;135:976-91.
30. Lane SF.The environmental sustainability of propofol in daily practice. BJA 2020;124(6): E221-222.
31. McGain F, Story D, Lim T, et al.. Financial and environmental costs of reusable and single-use

anaesthetic equipment. Br J Anaesth 2017; 118:862–869.
32. Sherman JD, Raibley LAIV, Eckelman MJ. Life Cycle Assessment and Costing Methods for Device Procurement: Comparing Reusable and Single-Use Disposable Laryngoscopes. Anesth Analg 2018; 127(2):434-443
33. Vozzola E, Overcash M, Griffing E. Environmental considerations in the selection of isolation gowns: A life cycle assessment of reusable and disposable alternatives. Am J Inf Control 2018; 46:881–886.
34. Eckelman M, Mosher M, Gonzalez A, et al.. Comparative Life Cycle Assessment of Disposable and Reusable Laryngeal Mask Airways. Anesth Analg 2012; 114(5): 1067-72
35. Bolten A, Kringos DS, Spijkerman IJB, et al.. The carbon footprint of the operating room related to infection prevention measures: a scoping review. J Hosp Infect 2022; 128:64–73
36. Lee S-T, Liang C-C, Chien T-Y, et al.. Effect of ventilation rate on air cleanliness and energy consumption in operation rooms at rest. Environ Monitor Assessm 2018; 190:178
37. Saadat, H, Raman VT. Environmentally Sustainable Anesthesia to Minimize Risks from Climate Change: a Societal Imperative or too Lofty a Goal?. Curr Anesthesiol Rep 2024;14: 57–62
38. White SM, Shelton CL, Gelb AW, et al.. Principles of environmentally-sustainable anaesthesia: a global consensus statement from the World Federation of Societies of Anaesthesiologists. Anaesthesia 2022; 77:201–212
39. McGain F, Muret J, Lawson C, Sherman JD. Environmental sustainability in anaesthesia and critical care. Br J Anaesth. 2020;125(5):680-692.