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REVIEW

Environmentally sustainable anaesthesia in a developing country – a narrative review

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Climate change is one of the leading threats to humanity today, and the practice of anaesthesia has an appreciable impact. This review will explore how anaesthesia, as part of the healthcare sector, significantly impacts climate change and how current literature can guide us in reducing our impact in South Africa.

Keywords: climate change, practices, anaesthesia, greenhouse gases, environment

Introduction

Climate change is one of the leading threats to humanity's long-term sustainability.[1] Although not often considered a significant contributor to emissions, the healthcare sector is one of the largest producers of greenhouse gas (GHG) emissions, one of the leading drivers of climate change.[1] According to the 2019 and 2020 reports of The Lancet Countdown on health and climate change, the healthcare sector contributes around 4.6% of global carbon emissions, which is gradually rising in first-world countries.[2,3] The global average temperature has risen by 1.2 degrees Celsius since preindustrial times.[2,3] These reports have estimated that globally, around 296 000 deaths have occurred since 2018 due to extremes in heat.[2,3] Children of today will experience a world where global warming and climate change will affect their health from infancy to old age.[2,3]

Anaesthesia, through its use of inhalation anaesthetic gases (IAG), intravenous agents, cleaning and sterilisation of reusable equipment, and production and disposal of single-use equipment, contributes heavily to the overall impact of the healthcare sector on the environment.[4,5] Professional anaesthetic societies are aware of the field's environmental impact and have taken a stance on the issue: The World Federation of Societies of Anaesthesiologists (WFSA) has created a global consensus statement on the principles of environmentally sustainable practices of anaesthesia.[5] The American Society of Anesthesiologists (ASA) has guidelines on environmentally sustainable anaesthetic practices.[4] Recently, the South African Society of Anaesthesiologists (SASA) has released a position statement on the environmental impact of IAGs.[6]

This review will explore how specifically anaesthesia, as part of the healthcare sector, has an appreciable impact on climate change and how the literature can guide its use in South Africa.

Mechanics of greenhouse gases

GHGs are classified according to their radiative efficiencies and their atmospheric lifetimes. Radiative efficiency refers to a measure of the gas's radiative forcing per unit change in the concentration of a gas in the atmosphere.[7] The specific "atmospheric lifetime" describes the timeframe that the GHG stays in the atmosphere.[7] These two metrics are incorporated into calculating the global warming potential (GWP) of GHGs. The Kyoto Protocol defines the GWP as "the heat absorbed by any GHG in the atmosphere, as a multiple of the heat that the same mass of carbon dioxide (CO_2) would absorb."[8] However, current literature has highlighted the controversy of using GWP as a quantifiable measure of the potential for harm.[9,10] Slingo and Slingo argue that IAGs cannot be equated to real CO_2 emissions and that their environmental impact is small.[9] Andersen et al.[10] maintain that several other factors must be considered when assessing the impact IAGs have on the environment, not just their CO_2 equivalence. Despite this controversy, the GWP is currently used as the metric to assess the environmental impact of IAGs by the Intergovernmental Panel on Climate Change (IPCC).[9,10]

The operating theatre and greenhouse gas emissions

Globally, it is estimated that 350 million general anaesthetics are performed annually.[1] South Africa is classified as an upper middle-income country, and thus, according to the Human Development Index, approximately 4 028 surgeries per 100 000 population are performed annually.[11,12] However, due to South Africa's public and private health systems, there is a disparity in the number of theatres per system.[11] There are 899 functional operating theatres in the public sector compared to 1 070 theatres in the private sector.[11]

For surgery to be performed, equipment, consumables, and drugs must be manufactured, packaged, procured, transported, and disposed of. Each of these steps contributes to GHG emissions. Most of the waste produced in operating theatres is from the surgical side.[10] However, anaesthesia also contributes extensively through the use of equipment and drugs.[10] Andersen et al.[10] estimated that the total emissions from inhaled anaesthetics used in 30 million anaesthetic procedures per year in the United States of America is equivalent to producing 660 000 tons of CO_2.

Contribution of inhalation anaesthetic gases to climate change

IAGs undergo negligible metabolism and are released almost completely unchanged into the atmosphere.[10] While they are present in the atmosphere at concentrations of around 100 000 times lower than other organic compounds, they have high GWPs, which renders them dangerous to the environment. Andersen et al.[10] estimated that, annually, the global emission of IAGs, as measured by their GWP, can be likened to the emission of 4.4 million tons of CO_2. Nitrous oxide (N_2O) remains in the atmosphere for 114 years.[10] The gas with the shortest atmospheric lifetime is sevoflurane, with a lifetime of 1.1 years.[10]

The global warming potential of specific inhalation anaesthetic gases

According to Andersen et al.,[10] the GWP "reflects the time-integrated radiative forcing due to a pulse emission of a unit mass of gas, normalised to the reference gas CO_2."[10] Climate groups created the GWP as a proxy measurement for GHGs' potential to cause harm to the atmosphere and it has been historically attached to IAGs.[9,10] However, current literature suggests that GWP is not well suited to IAGs. Instead, it is their atmospheric concentration, radiative forcing, and how climate systems respond to them that determines their overall impact on the environment.[9,10]

Desflurane

Desflurane has the greatest GWP of all the inhalation anaesthetics. The high GWP of desflurane is a result of it having the highest radiative efficiency combined with its longer atmospheric lifetime.[1] One gram of desflurane has the same GWP as 2 540 grams of CO_2.[1,13] Thus, a standard 240 ml vile of desflurane can contribute the equivalent of 893 kg of CO_2 to the atmosphere.[13] The underlying chemical property contributing to desflurane's GWP is the bond between fluorine and carbon, which is stronger than the bond between carbon and hydrogen, chlorine, or bromine found in the other IAGs.[13]

Nitrous oxide

N_2O remains a potent GHG since it has the longest atmospheric lifetime (about 114 years). It also has ozone-depleting potential.[13] Due to its low anaesthetic potency, N_2O needs to be administered at high concentrations during an anaesthetic.[14] In the United Kingdom, the "Nitrous Oxide Project" has been implemented. It is a quality improvement project aiming to improve "cleaner" N_2O delivery.[14] Most of the waste resulted from infrastructure leaks rather than use.[14] The project aims to decrease N_2O loss and waste.[14] It has resulted in the decommissioning of piped N_2O systems that were surplus to clinical need and some hospitals electing only to use N_2O cylinders to decrease the waste.[14]

Low-flow anaesthesia

Low flows (less than 2 L/min) are important as they prevent excess wastage of IAG from the circuit into the scavenging system and, finally, the atmosphere.[15] Modern anaesthetic machines combined with closed-circle breathing systems and CO_2 absorbers allow for low-flow anaesthesia to take place. IAG usage can be reduced by up to 80% when using low-flow techniques, which renders this technique favourable.[15] It was evidenced by Edmonds et al.[15] that there was a 48% drop in the expenditure of IAGs and a 42% reduction in emissions (equivalent to 33 tons of CO_2) when a fresh gas flow of 1 L/min was used, irrespective of the IAG used.

Anaesthetic equipment and life cycle assessments

Besides the environmental impact of using IAG, anaesthesia is also an equipment and consumable-heavy field.[1] Life cycle assessments (LCA) are fundamental when determining the extent of a product's environmental impact. A LCA is defined as "the environmental emissions of products, including raw material extraction, refining, manufacturing, packaging, transportation, clinical use, reuse, maintenance and waste management strategies."[16] LCAs of reusable anaesthesia equipment have concluded that they are often more economically beneficial than single-use equipment.[16] However, the environmental impact of reusable equipment still depends significantly on the source of electricity used for reprocessing these items in their respective countries. For example, LCAs of reusable equipment undertaken in Australia show higher carbon footprints than in New Zealand and Europe.[16,17] This is due to the source of energy used.

Infection risk associated with reusable equipment

The main concern with the use of reusable devices is infection. The actual risks are mainly linked to the patient's health status and the surgery itself rather than the type of anaesthetic devices and equipment used.[17] Reusable anaesthetic equipment does not necessarily confer infection risk and is more environmentally friendly.

Environmental impact of anaesthetic equipment

Eckelman et al.[18] found that reusable laryngeal mask airways (LMA) had a carbon footprint of 66% less than single-use LMAs and that 40 uses of one reusable LMA have a lower environmental impact than 40 disposable ones. The reasoning is that the production and polymerisation of polyvinyl chloride for disposable LMAs releases GHGs.[18] The ubiquity of single-use equipment in the operating theatre generates large amounts of waste and pollution. Reusable equipment decreases CO_2 emissions since there is less transportation involved in their distribution and less waste generation due to the nature of their reusability.[18] Therefore, it would be reasonable to campaign for the use of reusable equipment when possible. Most first-world countries use disposable anaesthetic devices, such as laryngoscope blades, endotracheal tubes, and ventilation masks.[18] In the South African public and private health setting, laryngoscope blades, blood pressure cuffs, and ventilation masks are reused due to cost concerns, and this can be appreciated as having a favourable environmental impact.[19]

Financial impact of reusable equipment

Due to less manufacturing and resource consumption, reusable equipment can also have economic benefits. McGain et al.[20] demonstrated a two-fold reduction in cost with reusable LMAs, laryngoscopes, and video laryngoscopes; the savings were estimated to be as high as 2.3 million AUD per year in Australia. This financially equated to saving approximately 5 000 AUD per operating room per annum.[20] An additional benefit of reusable devices is that the jobs of staff members involved in cleaning and sterilising these devices are maintained.[20] Further savings occur because there are fewer logistical costs involved with reusable equipment due to less waste disposal and incineration.[20]

The environmental impact of intravenous anaesthetic agents

LCAs of intravenous agents have shown that they harm the environment, but the overall environmental impact of IAGs remains greater.[20] The WFSA and ASA have taken a standpoint and formally proposed that regional anaesthesia and total intravenous anaesthetic (TIVA) should be considered first, if clinically applicable, instead of IAGs.[4,5] However, the SASA position statement does not have explicit guidelines on the use of TIVA.[6] It only recommends that the one with the lowest environmental impact be considered when anaesthetic techniques are clinically equivalent.[6] The most common agent for TIVA is propofol.[21]

Ecotoxicity of propofol

Unused propofol is the most wasted medication by volume.[21] The complete ampoule of propofol is commonly drawn up, but the entire volume is not always utilised, with the remaining amount discarded. It is often incorrectly discarded into municipal drains via hospital wastewater. Little is known or has been documented regarding the ecotoxicity of the inactive metabolites, but it is assumed that they have the same ecotoxicity as the parent drug.[21] It is known that under aerobic and anaerobic conditions, propofol does not normally undergo substantial biodegradation.[21]

Effect of propofol on marine life

Propofol is an environmentally toxic agent for aquatic life.[21] The aquatic half-life of propofol is more than one year.[21] Propofol can accumulate in certain aquatic organisms due to its fat solubility. Although bioaccumulation analyses of propofol in fish have shown a low risk for bioaccumulation, there are limited studies regarding the long-term exposure of fish to propofol.[21] Longer studies have been conducted on algae and small crustaceans, which have shown that propofol causes growth inhibition and death of algae, as well as toxicity in crustaceans.[21] For the drug to be fully removed from waste, propofol needs to be incinerated at more than 1 000 degrees Celsius for over two seconds.[21] Hence, it must be discarded in specific containers for hazardous pharmaceutical waste that will be incinerated.

The global consensus statement from the World Federation of Societies of Anaesthesiologists

The WFSA established a working group of 45 anaesthetists with a special interest in environmental sustainability.[5] The consensus principles for environmentally sustainable anaesthesia are as follows:[5]

- Patient safety should not be compromised by the practice of sustainable anaesthesia.
- High-, middle- and low-income countries should support each other appropriately in delivering sustainable healthcare.
- Healthcare systems should be mandated to comply with a reduction in their contribution to global warming.
- Minimise the environmental impact of clinical practice.
- Use environmentally favourable medications and equipment when deemed clinically safe.
- Reduce the waste of medications, equipment, energy (electricity or gas), and water.
- Incorporate environmentally sustainable principles within formal anaesthetic education.
- Embed environmentally sustainable principles within anaesthetic research and quality improvement programmes.
- Lead environmentally sustainable activity and ideas within their healthcare organisations.
- Collaborate with the industry to improve environmentally sustainable practices and innovation.

The American Society of Anesthesiologists

The ASA has created a comprehensive guideline on the practice of environmentally sustainable anaesthesia. This guideline provides directives for the appropriate choices of anaesthetic equipment, the correct use of IAGs, the management of FGF, the correct protocols for the disposal of unused intravenous agents, the best practices for waste management, and the implementation of sustainable recycling methods.[4] The ASA has also created an Anesthesiology Sustainability Checklist that incorporates the actual practical execution of the above guidelines.[4]

South African Society of Anaesthesiologists practice guidelines

There are limited South African guidelines and policies on the practice of environmentally sustainable anaesthesia. SASA has created a position statement on the environmental impact of IAGs. The latest SASA guidelines refer to the following:[6]

- Patient safety and clinical outcomes are of primary importance.
- If different anaesthetic techniques are available, consideration should be given to the technique with the least environmental impact.
- N_2O usage should be limited. Its use should be restricted to only specific cases, and if used, N_2O E-cylinders should be used instead of piped N_2O.
- Desflurane usage should be restricted.

- When IAGs are used, the lowest possible FGF should be utilised, and the IAGs should be used for the shortest possible time.

College of Medicine of South Africa curriculum

The College of Medicine of South Africa has a formal curriculum guideline to which all South African-trained anaesthetists must adhere to complete their formal specialisation and earn their subsequent admission as a Fellow to the College of Anaesthetists.[22] The practice of environmentally sustainable anaesthesia is not mentioned in any domain or section, and the curriculum does not encourage specific environmentally sustainable practices.

Current knowledge and practices of South African anaesthetists on environmentally sustainable anaesthesia

Limited published studies exploring South African anaesthetists' knowledge of environmentally sustainable anaesthetic practices exist as proposed by the WFSA and ASA guidelines. However, some studies have considered a particular aspect of environmental sustainability. Frewen et al.[19] assessed the opinions and knowledge of South African anaesthetists regarding the environmental impact of anaesthetic practice. It was found that South African anaesthetists appear to want to adopt environmentally friendly practices in the operating theatre; however, barriers prevent implementation.[19] It was further found that anaesthetists lack the necessary knowledge and education to guide them towards a more sustainable practice.[19]

Conclusion

Training anaesthetists to practice in an environmentally sustainable manner is vital to limit climate change, given the world's present predicament. IAGs contribute to ozone depletion and global warming, and how they are used in clinical practice has a direct contribution. Single-use equipment can worsen pollution, and it has been shown that reusable equipment is safe to use and better for the environment. Propofol is an environmentally toxic agent, and its correct disposal is fundamental to prevent further destruction to marine life. A large body of international literature exists regarding the knowledge and practices of environmentally sustainable anaesthesia; however, very few South African studies have examined these subjects. Finally, more expansive guidelines relating to our context are required to encourage South African anaesthetists to practice in an environmentally sustainable manner.

Conflict of interest

The authors declare no conflict of interest.

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