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Anesthesia and Greenhouse Gases Emissions

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Abstract

Global warming is one of the biggest threats of our time, and it is primarily caused by human activities. While anesthesia is an essential component of modern medicine and is used to provide patients with pain relief and sedation during surgery and other medical procedures; the use of anesthetic agents has been linked to the production of greenhouse gases, which contribute to global warming and climate change. This has led to increased interest in understanding the environmental impact of anesthesia and identifying ways to reduce its carbon footprint. The primary greenhouse gases associated with anesthesia include nitrous oxide and desflurane, both of which are potent contributors to climate change. Nitrous oxide is particularly concerning as it has a long atmospheric lifetime and is nearly 300 times more potent than carbon dioxide in terms of its global warming potential. Desflurane, while less potent than nitrous oxide, has a very high carbon footprint due to its production process and high rate of release into the atmosphere during use. There are a number of strategies that can be employed to reduce the environmental impact of anesthesia. These include using more efficient anesthetic delivery systems, switching to less environmentally harmful agents, and minimizing waste and leaks. Additionally, efforts can be made to raise awareness among healthcare providers and patients about the importance of reducing greenhouse gas emissions from anesthesia.

Keywords: anesthesia, carbon footprint, global warming, greenhouse gases emissions

Introduction

Anesthesia is a critical component of many medical procedures, but it also has a significant impact on greenhouse gas (GHG) emissions, the release of gases into the Earth's atmosphere that trap heat and contribute to the greenhouse effect, leading to global warming and climate change. Overall, the impacts of these emitted gases are wide-ranging and significant, affecting many aspects of human society and the environment. It is important to reduce GHG emissions to mitigate these impacts and address the climate crisis.[1,2]

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In anesthesia practice, the use of volatile anesthetics is a major source of the emissions in the healthcare industry. Consequently, there are several ways to address the impact of anesthesia on GHG emissions. One approach is to use alternative anesthetics that have lower global warming potentials. For example, intravenous anesthetics have a much lower impact on greenhouse effects compared to volatile anesthetics. Another approach is to reduce the amount of anesthetic gas used during procedures. This can be achieved through various measures, such as using closed-loop anesthesia systems, using low-flow anesthesia, or minimizing the time the patient spends under anesthesia.[2,3] Anesthesia professionals can also take steps to improve the sustainability of their practice by adopting environmentally conscious behaviors. This can include reducing waste, recycling, and using energy-efficient equipment. Additionally, anesthesia providers can work with manufacturers to improve the environmental sustainability of anesthesia drugs and equipment.[2-6]

Terms associated with carbon emissions

It is important for medical personnel to become familiar with the various terms associated with carbon emissions in manufacturing processes. For example, businesses and industries use *life cycle assessment* (LCA) and *carbon footprint analysis* to pinpoint areas of high carbon emissions in their managerial processes and adopt measures to reduce their carbon footprint. Accurate calculation of carbon emissions requires the use of *material data sheets* (MDS) and monitoring *energy consumption of equipment*. As a result, *carbon offsetting* is often employed to minimize the overall impact of carbon emissions.[7,8] LCA is a methodology that assesses the environmental impacts of a product or service throughout its entire life cycle, from the extraction of raw materials to the disposal of the product. LCA can be used to calculate the amount of carbon emissions associated with the production, transportation, use, and disposal of medical equipment.[2,9,10] Carbon footprint analysis is a method that calculates the total amount of greenhouse gases (GHG) emissions caused by a product or service. This can be used to estimate the amount of carbon in medical equipment, such as syringes, anesthetic gases, needles, and sponges.[11,12]

MDS can be used to determine the amount of carbon in many manufacturers' products. For example, the MDS for a syringe may indicate the percentage of carbon in the plastic or rubber used to make the syringe.[9,13,14] Energy consumption of the equipment can be used to measure the amount of carbon in the materials, and then convert the energy consumption to carbon emissions using conversion factors.[15,16] Carbon offsetting is a way of compensating for the carbon emissions associated with a product or service by investing in projects that reduce or remove an equivalent amount of carbon from the atmosphere. Carbon offsetting can be used to estimate the amount of carbon in medical equipment by calculating the amount of carbon that would need to be offset in order to neutralize the emissions associated with the equipment.[16,17] However, it is important to note that the amount of carbon in medical

equipment may vary depending on the materials used, the production process, and specific data available for the specific equipment from the suppliers.

Greenhouse gases emissions

The most common GHG are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (Table 1). These gases are emitted by various human activities such as burning fossil fuels for energy, deforestation, agriculture, and industrial processes. The concentration of GHG in the atmosphere has increased significantly since the Industrial Revolution, and it is a major cause of the current climate crisis, including:[18]

1. GHG has caused the earth's temperature to rise, leading to climate change. This has resulted in more frequent and severe weather events such as heatwaves, droughts, floods, hurricanes, and wildfires, which have significant impacts on the environment, infrastructure, and human health.[11,18]

2. The increase in global temperatures is causing the melting of glaciers and polar ice caps, leading to sea-level rise. This has significant impacts on coastal communities, causing flooding, erosion, and loss of infrastructure. The increase in CO_2 emissions is also causing the oceans to become more acidic, together with N_2O can contribute to acid rain and can also contribute to the eutrophication of water bodies, which has negative impacts on marine ecosystems and fisheries.[18]

3. Climate change and air pollution caused by GHG emissions have significant impacts on human health, including respiratory illnesses, cardiovascular diseases, and heat-related illnesses. Consequently, it can have significant economic impacts, including damage to infrastructure, loss of agricultural productivity, and increased costs associated with extreme weather events, such as El Niño and La Niña phenomenon.[18]

Anesthesia and greenhouse gas emissions

Anesthesia is a critical component of modern medicine and is used in a wide range of medical procedures, from minor surgeries to major operations. The impact of anesthesia GHG emissions has been a growing concern in recent years as it is typically administered by inhalation or injection of anesthetic gases or drugs. The most commonly used inhalation agents, such as N_2O, desflurane, and sevoflurane, are potent GHG that contribute to global warming (Table1).[2,6,8,19]

N_2O, a long atmospheric lifetime, is known for its ability to reduce pain and anxiety. However, it is also a potent GHG, with a global warming potential that is over 300 times greater than that of CO_2. N_2O is estimated to be responsible for around 5% of all GHG emissions generated by human activity.[6,8,19,20] Desflurane is an anesthetic gas with a global warming potential that is over 2,500 times greater than that of CO_2. Although less commonly used than N_2O, it still significantly contributes to GHG emissions.[6,8,19-21] Sevoflurane has a lower global warming potential than both N_2O and desflurane. However, it is still a GHG and contributes to climate change.[6,8,19,21] In addition to the direct emissions of anesthetic

Table 1 Global warming potentials and atmospheric lifetimes[23,32]

Greenhouse gases/ Inhalational agents	Atmospheric lifetimes	Global warming potentials (CO_2 equivalent)
Greenhouse gases		
Carbon dioxide (CO_2)	200-450	1
Methane (CH_4)	11	21
Nitrous oxide (N_20)	120	310
Hydrofluorocarbon (HFCs)	2-19	140-11,700
Perfluorocarbon (PFCs)	>1,000	6,500-9,200
Sulfur hexafluoride (SF_6)	3,200	23,900
Inhalational agents		
2% sevoflurane	1.2	130
1.2% isoflurane	3.2	510
6% desflurane	14	2,540
Nitrous oxide	114	298

gases during medical procedures, there are also indirect emissions associated with the production and transportation of these gases. Anesthetic gases are typically produced in large quantities and transported around the world, resulting in significant carbon emissions. In the United States, anesthetic gases are estimated to be responsible for around 3-5% of the total GHG emissions from the healthcare sector.[22] This is equivalent to the emissions generated by around 2.5 million cars per year. A single operating room can produce more than 2,000 kg of CO_2 equivalents per day, with up to 5% of a hospital's total GHG attributed to anesthesia.[2,4,19]

According to a previous study, the annual global emissions of N_2O from anesthesia were estimated to be around 200 million metric tons of CO_2 equivalent. This accounts for around 1% of total global GHG emissions.[23] The annual emissions of all anesthetic gases combined including N_2O, desflurane, and sevoflurane were around 210 million metric tons of CO_2 equivalent. This accounts for around 3% of total GHG emissions from the healthcare sector.[2,7,11] The largest contributor to the carbon footprint of anesthesia was N_2O, which accounted for around 60% of total emissions or around 5.4 kg CO_2 equivalent per general anesthetic. This includes both direct emissions from anesthetic gases and indirect emissions associated with production and transportation.[9,16]

Apparently, healthcare facilities are significant contributors to environmental pollution and GHG emissions. A typical hospital uses three times more energy per square foot than a typical office building. The majority of this energy consumption is attributed to the operation of medical equipment, heating and cooling systems, and lighting. The increased demand for energy often results in the burning of fossil fuels, which contributes to greenhouse gas emissions and the acceleration of climate

change. In addition, healthcare facilities generate a significant amount of waste, including hazardous and non-hazardous materials, which can have negative impacts on public health. This includes increased rates of infectious diseases, respiratory illnesses, and malnutrition. Therefore, it is the responsibility of healthcare facilities to take action to reduce their environmental footprint, adopt more sustainable practices, and implement new technologies to protect the environment for future generations.[18]

How to reduce GHG emissions

Raising awareness among healthcare professionals and patients, as well as tracking progress and monitoring GHG emissions from healthcare facilities, can help identify opportunities to reduce emissions and encourage more sustainable practices regarding the environmental impact of anesthesia. This can contribute to mitigating the harmful effects of GHG emissions on the environment and public health. There are several strategies and technologies that can be used to reduce the environmental impact of anesthetic gases. These include using alternative anesthetic agents that have a lower global warming potential. For example, propofol is a commonly used alternative to N_2O and has a much lower impact on the environment.[3]

Another way is to use more efficient anesthetic delivery systems. For example, closed-circuit anesthesia systems can capture and reuse anesthetic gases, reducing the need for new gas supplies and minimizing emissions. In addition, it is important to reduce the use of unnecessary anesthesia, such as in outpatient procedures that could be performed under local anesthesia.[3] Additionally, recycling anesthetic gas can help reduce the amount of gas that is released into the atmosphere. Recycling systems can capture and clean used anesthetic gas, making it available for reuse in subsequent procedures. Also, minimizing waste from packaging and other materials associated with anesthesia can also help reduce the environmental impact.[3,24] Furthermore, some healthcare facilities are exploring the use of renewable energy sources, such as solar and wind power, to power their operations. This can help reduce the overall carbon footprint of anesthesia and other healthcare activities.[25]

Implementing strategies

Remarkably, University College London Hospitals implemented a program to reduce their carbon footprint, including reducing emissions associated with anesthesia.[26] They switched from using N_2O to sevoflurane as their primary anesthetic agent, resulting in a significant reduction in emissions. They also implemented a recycling program for anesthetic gases, which further reduced their environmental impact.[27,28] Yale New Haven Hospital implemented a closed-circuit anesthesia system, which captures and recycles anesthetic gases. This system reduced the hospital's emissions from anesthesia by 90%.[2,29,30] As well, Kaiser Permanente, a large healthcare organization in the United States, has implemented a range of sustainability initiatives, including reducing emissions associated with anesthesia. They have switched to using low-global-warming-potential

anesthetic agents, implemented efficient delivery systems, and increased education and awareness among healthcare providers.[31]

Challenges and potential solutions

Reducing GHG emissions associated with anesthesia is not an easy task, due to:

1. Healthcare providers may not be aware of the environmental impact of anesthesia or the available strategies for reducing emissions. There may be resistance among healthcare providers to change their practices, particularly if they have been using the same anesthetic agents and delivery systems for many years. This can be due to concerns about patient safety, lack of awareness about the environmental impact of anesthesia, or simply a reluctance to change established practices.

Solutions: Increasing education and training for healthcare providers could help overcome resistance to change.

2. Regulatory requirements may make it difficult to implement new technologies. For example, some anesthetic agents may be required for certain surgical procedures or may be required by regulatory compliance to maintain ethical and legal standards in various medical institutes.

Solutions: Governments could facilitate revisions to regulatory requirements to enable healthcare facilities to collaborate with other organizations or industry partners, thereby promoting the sharing of knowledge and resources. This collaborative effort could potentially lower costs and eliminate regulatory barriers.

3. The limited availability of alternative anesthetic agents. Some of the commonly used anesthetic agents, such as N_2O and desflurane, have a high global warming potential. However, alternative agents with lower global warming potential, such as propofol and sevoflurane, are not always readily available or may be more expensive.

Solutions: Encouraging the development and promotion of alternative anesthetic agents could help to reduce emissions associated with anesthesia.

4. Implementing sustainable practices can be expensive. Hospitals and healthcare facilities may not have the financial resources to invest in new technologies or switch to alternative anesthetic agents.

Solutions: Governments or other organizations could offer financial incentives to healthcare facilities. This could help to offset the costs of implementing new technologies.

Call for further researches

Despite growing awareness of the impact of anesthesia on greenhouse gas emissions, there is still much to learn about this issue. As such, there is a need for further research and collaboration to better understand the impact of anesthesia on the environment and to develop effective strategies to mitigate this impact. One area that requires further research is the development of alternative anesthetic agents with lower global warming potential. While several alternative agents have been developed, there is still a need to evaluate their safety and efficacy and to determine their impact on the environment. Further research is also needed to

determine the optimal use of these agents and to develop protocols for their use. Another area that requires further research is the impact of anesthesia delivery systems on GHG emissions. While closed-circuit anesthesia systems have been shown to significantly reduce the emissions, there is still a need to evaluate their safety and effectiveness and to determine the optimal use of these systems. Further research is also needed to develop new delivery systems that are both effective and environmentally sustainable.

Conclusion

Anesthesia plays a vital role in ensuring patient safety and comfort during surgical procedures. However, the use of anesthesia and commonly delivery systems, release anesthetic gases into the atmosphere, also has a significant impact on GHG emissions, thereby contributing to climate change and global warming by consuming large amounts of energy during production, operation, transportation, and storage. Most of all, to reduce GHG emissions associated with anesthesia requires a concerted effort from healthcare providers, policymakers, and industry partners. Further research and collaboration are essential to developing effective strategies to mitigate the impact of anesthesia on the environment and to promote sustainability in healthcare.

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