Impact of anaesthetic gases on climate change

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▶ **Citation:** Müller S, Wulf H: Impact of anaesthetic gases on climate change.
Anästh Intensivmed 2023;64:418–425. DOI: 10.19224/ai2023.418

Summary

Climate change is a major threat to global health. We anaesthesiologists also have a responsibility to take action to limit global warming. The healthcare sector is a relevant emitter of greenhouse gases. The anaesthetic gases isoflurane, desflurane and sevoflurane belong to the group of chlorofluorocarbons or fluorocarbons and are counted among these greenhouse gases, just like nitrous oxide. In particular, the inhalation anaesthetic desflurane has pronounced negative effects on the climate.

With the preferred use of the less harmful sevoflurane, the carbon footprint can be significantly improved. To reduce anaesthetic gas consumption, the fresh gas flow should be kept as low as possible. Total intravenous anaesthesia with propofol or regional anaesthesia can also reduce greenhouse gas emissions. Vapour capture technology should be considered.

Introduction

Man-made climate change presents us all with a very big task. The Paris Agreement of 2015, which was adopted by 195 countries, envisages limiting global warming to well below 2°C compared to the pre-industrial era. Efforts are also made to limit the temperature increase to 1.5°C if possible. To achieve this 1.5°C target, it is necessary to significantly reduce greenhouse gas emissions by 2030 and to reduce them to net zero by 2050 [1]. If this goal is not achieved, there is a threat of global warming with increased extreme weather events, rising sea levels, destruction of housing, loss of biodiversity, a crisis in global health, water scarcity, famine, mass migration and geopolitical destabilisation [2,3]. From a global warming of more than 1.5°C, the risk of crossing so-called tipping points (such as thawing of permafrost soils, melting of large ice masses) increases significantly [3].

The World Health Organisation describes climate change as the greatest threat to global health and expects an additional 250,000 deaths per year as a result of global warming [4]. It is estimated that 150,000 deaths per year worldwide can be attributed to heat waves caused by climate change [3]. For Germany, this figure is at around 1,200 deaths per year.

Last but not least, the position paper of our professional societies on ecological sustainability in anaesthesiology and intensive care medicine highlights our special responsibility as anaesthesiologists to limit global warming [5]. This selective literature review will consider the effects of anaesthetic gases on the global climate and what strategies exist to limit climate-damaging effects of anaesthetic gases.

Greenhouse gases and greenhouse effect

Global warming is caused by the increased emission of so-called greenhouse

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Competing interests
The authors declare no competing interests.

Keywords
Inhalation Anaesthetics – Sevoflurane – Desflurane – Climate Change – Carbon Footprint

gases and their increased concentration in the atmosphere [1]. Greenhouse gases include carbon dioxide, methane, nitrous oxide and fluorinated greenhouse gases.

The Earth's atmosphere is largely transparent to solar radiation. The atmosphere is less transparent to the Earth's thermal radiation – and the more greenhouse gases there are in the atmosphere, the less transparent it is. The difference between incoming and outgoing radiation is called radiative forcing [6]. The increased concentration of greenhouse gases leads to global warming – the so-called greenhouse effect – by changing the radiative forcing [7]. The extent of the greenhouse effect of a gas is determined by its atmospheric lifetime, its ability to absorb thermal radiation and the presence of natural substances that absorb thermal radiation in the same wavelength range [8].

In the Montreal Protocol of 1987, it was decided to phase out the use of chlorofluorocarbons in order to protect the ozone layer. This resulted in an increased use of hydrofluorocarbons, which have no ozone-depleting effect but are potent greenhouse gases. An amendment protocol from 2016 led to the elimination of hydrofluorocarbons as far as possible. Anaesthetic gases were exempted from these decisions. [8]

Anaesthetic gases and the greenhouse effect

Globally, the health sector accounts for 4.4–4.6 % of greenhouse gas emissions. [9] In western countries, this share is higher and is reported to be at around 5–10 % of all greenhouse gas emissions [1]. In the USA, for instance, it is 10 % [10]. In its 2019 report, the non-governmental organisation Health Care Without Harm states that the health care system in Germany accounts for 5.2 % of national greenhouse gas emissions [11]. This corresponds to an annual emissions of 58 million tons of CO_2 equivalent.

Anaesthetic gases enter the atmosphere almost completely and unchanged due to the low metabolisation rate and mostly missing filter systems.[4] There they can exert effects on global warming as greenhouse gases. How much anaesthetic gas is consumed and emitted nationally and internationally and what consequences this has on the global greenhouse effect is only inaccurately surveyed or estimated and not in a standardized manner.

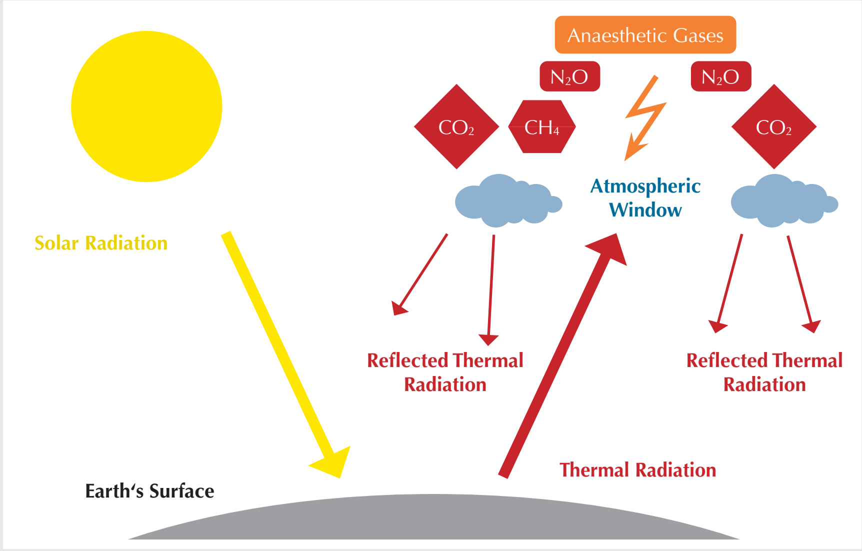
In the UK, 5 % of total emissions from hospitals can be attributed to anaesthetic gases [2]. According to Health Care Without Harm, anaesthetic gases (including nitrous oxide) are responsible for at least 0.6 % of global greenhouse gas emissions from the healthcare sector.[11] In the USA, 0.1 % of national greenhouse gas emissions or 1 % of those from the healthcare sector are caused by the release of anaesthetic gases.[4]

The volatile anaesthetics isoflurane, desflurane and sevoflurane belong to the halogenated hydrocarbons [12]. Isoflurane is a chlorinated and fluorinated methyl ethyl ether – and thus belongs to the group of chlorofluorocarbons [8,12]. In the case of desflurane, the chlorine atom of isoflurane has been replaced by fluorine. Desflurane is therefore a fluorinated methyl ethyl ether. Just like desflurane, sevoflurane does not contain chlorine. Sevoflurane is a methylpropyl ether fluorinated with 3 fluorine atoms [12]. Desflurane and sevoflurane are counted among the group of hydrofluorocarbons [8].

As chlorofluorocarbons or hydrofluorocarbons, the volatile anaesthetics isoflurane, sevoflurane and desflurane are among the fluorinated greenhouse gases [7]. The greenhouse effects of volatile anaesthetics are due in particular to the fact that they absorb thermal radiation in the so-called atmospheric window (Figure 1). The atmospheric window refers to a wavelength range in which the atmosphere is particularly permeable to radiation [8].

The impact of a gas on the greenhouse effect is described with the Global Warming Potential (GWP). The GWP of a greenhouse gas corresponds to the mass of carbon dioxide with the same effect on the equilibrium of the Earth's radiation energy over a certain period of time [13]. When determining the GWP for anaesthetic gases, different authors provide different results [14–16]. The reason for this is different initial data and calculation methods [14]. In this review we refer to the data from a paper by Andersen et al. (Table 1) [16]. Desflurane in particular has pronounced

Figure 1



Schematic presentation of the greenhouse effect. In particular, the so-called atmospheric window is shown in which volatile anaesthetics absorb thermal radiation.

Table 1
Atmospheric Lifespan and Global Warming Potential of anaesthetic gases [16].

	Atmospheric Lifespan [Years]	GWP20	GWP100	GWP500	Ozone-damaging
Isoflurane	3.2	1,800	510	160	X
Sevoflurane	1.1	440	130	40	
Desflurane	14	6,810	2,540	130	
Nitrous oxide	114	289	298	153	X

GWP: Global Warming Potential.

greenhouse effects. The GWP20 of desflurane is 6,810. Consequently, 1kg of desflurane has the same effects as 6,810 kg of carbon dioxide over a period of 20 years. Due to an atmospheric lifetime of 14 years, the GWP100 is lower and is 2,540 for desflurane. The effects of sevoflurane on global warming are significantly lower. A value of 440 is given for the GWP20 of sevoflurane. Due to the comparatively short atmospheric lifetime of 1.1 years, the long-term greenhouse effects of sevoflurane are also less pronounced (GWP100 130). An overview of the GWP of the various anaesthetic gases is shown in Table 1.

Nitrous oxide forms a separate group among greenhouse gases [1]. It unfolds its enormous greenhouse effects mainly through its long atmospheric lifetime [8]. In addition to the greenhouse effects described, nitrous oxide and the chlorinated or brominated anaesthetic gases isoflurane and halothane deplete the ozone layer in the atmosphere [4]. Sevoflurane and desflurane contain neither chlorine nor bromine atoms and therefore do not have any ozone-damaging effect.[4]

Using GWP100, the contents of a bottle of desflurane (240 ml) are equivalent to 886 kg of carbon dioxide; the contents of a bottle of sevoflurane (250 ml) are equivalent to 49 kg of carbon dioxide [6]. Due to its lower anaesthetic potency, it should be added that the consumption of desflurane per minute of anaesthesia is approximately three times higher than that of sevoflurane (MAC50 of desflurane 6.0 % by volume, of sevoflurane 2.04 % by volume) [17].

In Australia, desflurane accounted for 21 % of all anaesthetic gases purchased in 2014 [4]. However, desflurane was responsible for 81 % of the greenhouse gas emissions of all anaesthetic gases [4]. In Germany, sevoflurane was the preferred anaesthetic gas in 2012, accounting for 55 % of the total [1]. Desflurane and isoflurane were used in 35 % and 10 % of anaesthetics administered with anaesthetic gases respectively.

The annual consumption of anaesthetic gases worldwide is estimated at approx. 12.5 million cylinders with the following distribution: 70 % sevoflurane, 20 % desflurane and 10 % isoflurane [2]. This corresponds to a CO_2 equivalent of approx. 5 million t CO_2 and thus a share of approx. 0.01 % of global CO_2 emissions [2]. Increasing concentrations of isoflurane, desflurane and sevoflurane were measured in air samples at various locations around the world from 2000 to 2014 [18]. From these data, global emissions of anaesthetic gases were determined in a top-down model. These calculations showed that the emissions of isoflurane, desflurane and sevoflurane increased during the observation period. Taking GWP100 as a basis, this corresponds to a CO_2 equivalent of 3.1 ± 0.6 million t CO_2 in 2014. Approximately 80 % of this is attributable to desflurane. It should also be noted that the atmospheric halothane concentration decreased during the period under study. This is due to decreasing consumption and shows that changing the use of anaesthetic gases can have an impact on the atmosphere. A rough extrapolation based on the consumption figures of the University Hospital of Michigan (annual consumption in Michigan: 1,081 l isoflurane, 6 l desflurane, 505 l sevoflurane) resulted in a global emission of anaesthetic gases corresponding to a CO_2 equivalent of approx. 4.4 million t CO_2 [7].

If one wants to make the climate-damaging effects of anaesthetic gases comparable in clinical use, it is useful to consider the CO_2 equivalent of an anaesthesia. To do this, one calculates the mass of an anaesthetic gas that is necessary to maintain an anaesthesia with 1 MAC for the duration of one hour (corresponding to one MAC-hour) using a certain fresh gas flow. Multiplying this mass by the GWP of the anaesthetic gas yields the corresponding CO_2 equivalent (CDE) (Table 2) [19].

Table 2
Anaesthetic gas consumption and CDE20 per MAC-hour [19]. Supplemented by own calculations for a fresh gas flow of 1l/min according to [14,19].

	Fresh gas flow	Consumption [g/h]	CDE20 [g/h]
Sevoflurane	0.5 l/min	5	2,200
Sevoflurane	1 l/min	10	4,400
Sevoflurane	2 l/min	20	8,800
Isoflurane	0.5 lmin	2,8	5,000
Isoflurane	1 l/min	5,6	10,000
Isoflurane	2 l/min	11.1	20,000
Desflurane	0.5 lmin	12.6	85,800
Desflurane	1 l/min	25.2	171,600
Desflurane	2 l/min	50.4	343,200

CDE: CO_2 equivalent; **MAC:** Minimum Alveolar Concentration.

In 2 life cycle analyses, taking into account production, transport, application as well as disposal and emissions into the atmosphere, significantly higher greenhouse gas emissions were determined with the use of desflurane compared to sevoflurane or isoflurane [20,21]. The calculated emissions when using propofol (1 MAC equivalent) were significantly lower (up to almost 10,000-fold) than of those when using desflurane. The carbon footprint of propofol was also mostly lower compared to sevoflurane. If an anaesthetic gas filter system was used and the recovered sevoflurane was used, sevoflurane had the same greenhouse footprint as propofol [21]. If one excludes the direct greenhouse effects of the anaesthetic gases in the atmosphere, the electricity consumption for heating the desflurane vapour causes a relevant proportion of the greenhouse gas emissions. Furthermore, both studies show that the use of anaesthetic gases in a nitrous oxide-oxygen mixture leads to significantly higher greenhouse gas emissions than in an air-oxygen mixture.

In 3 hospitals from North America and the UK, the greenhouse gas emissions of the respective operating theatre areas were investigated [22]. In the two North American hospitals, anaesthetic gases were responsible for 63 % and 51 % of the total emissions of the operating theatre areas (2,034,277 kg CO_2 equivalent per year and 2,129,841 kg CO_2 equivalent per year, respectively). In the UK hospital, despite more anaesthesia services (30,000 services per year compared to 18,000–20,000 services per year), anaesthetic gases accounted for only 4 % of the total emissions of the operating theatre area there (211,212 kg CO_2 equivalent per year). This fact becomes clear when looking at the consumption figures for anaesthetic gases: the clinics in North America prefer to use desflurane in addition to isoflurane and sevoflurane (535.7 l per year and 532.8 l per year desflurane); desflurane is not used in the British clinic. The authors did not provide information on the proportion of regional anaesthesia procedures or the use of TIVA.

In a hospital providing extended basic and standard care in Germany, it was shown that the limited use of desflurane can lead to significantly lower greenhouse gas emissions [3]. In the compared year, in which desflurane and sevoflurane were used equally, the authors determined a consumption of 77.8 l of desflurane and 82.5 l of sevoflurane. In the following year, the consumption of desflurane could be reduced to 4.3 l. Correspondingly, the consumption of sevoflurane increased to 105 l. This led to a 68 % reduction in total emissions from the corresponding anaesthesia department. The share of anaesthetic gases in total emissions was reduced from 77 % to 28.5 %.

Strategies to reduce the climate-damaging effects of inhalation anaesthetics

As described in detail before, the use of sevoflurane – especially instead of desflurane – can reduce the impact of inhalation anaesthesia on the greenhouse effect many times over. Accordingly, the „Sustainability in Anaesthesiology“ commission of the DGAI and BDA recommends limiting the use of desflurane to those situations in which it is urgently indicated medically (Fig. 2) [5].

Furthermore, negative consequences for both climate change and the ozone layer can be avoided by omitting the use of nitrous oxide. Especially in combination with isoflurane or sevoflurane, nitrous oxide significantly worsens the climate balance of inhalation anaesthesia [14].

Figure 2

Use desflurane only in situations where it is medically required
Avoid nitrous oxide
Keep fresh gas flow as low as possible
Monitor depth of anaesthesia
Use automatic control of end-tidal anaesthetic gas concentration
Consider collection systems

Principles for a climate-friendly use of inhalation anaesthetics.

It is not only the choice of anaesthetic gas that has an impact on the climate – the level of fresh gas flow also determines the greenhouse effects of inhalation anaesthesia. The amount of anaesthetic gas consumed is proportional to the level of fresh gas flow [14]. For example, reducing the fresh gas flow from 1 l/min to 0.5 l/min leads to a halving of the anaesthetic gas consumed (at the same setting on the vapour). If a higher anaesthetic gas concentration is set on the vapour to achieve the same alveolar concentration at a lower fresh gas flow, this also results in lower anaesthetic gas consumption [23]. If rapid changes in anaesthetic depth are necessary, a higher fresh gas flow can hardly be avoided. However, it should be noted that – provided the inspiratory gas concentration corresponds to the concentration set on the vapour – any further increase in the fresh gas flow cannot lead to any further change in the depth of anaesthesia [23]. Towards the end of anaesthesia, the attentive anaesthetist will turn off the vapour early if the fresh gas flow is low, in order to allow the patient to wake up precisely at the end of the operation. If higher fresh gas flows are necessary for emergence, this should only be done with the vapour closed [5]. It should not go unmentioned that the reaction of sevoflurane with soda lime can lead to the formation of the potentially nephrotoxic compound A, which in the past led to a restricted use of sevoflurane in low-flow anaesthesia. This guideline is now considered obsolete. Relevant formation of compound A can be ruled out, especially when calcium chloride-containing carbon dioxid absorbers are used. The use of sevoflurane with minimal fresh gas flow is nowadays considered safe and can be performed without restrictions in this regard [24].

Automatic control of end-tidal anaesthetic gas concentration and the use of anaesthetic depth monitoring may also help to reduce consumption [4,25,26].

Another way to reduce the emission of anaesthetic gases into the environment is to use anaesthetic gas absorber systems [27]. In Germany, such a system has been available since 2011 (CONTRAfluran, ZeoSys Medical GmbH, Luckenwalde, Germany). It was initially used in the context of inhalation-guided sedation in intensive care medicine and has been used in anaesthesia since 2020 [28]. The filter system is connected to the anaesthetic gas outlet of the anaesthesia machine and can be operated with or without an anaesthetic gas scavenging system (AGSS), depending on the design. The anaesthetic gases isoflurane, desflurane and sevoflurane can be absorbed. Capturing nitrous oxide is not possible with this system. A drug authorisation for the recovered sevoflurane has existed since 2017 [28]. So far, the sevoflurane produced by recycling cannot be purchased [29]. According to the manufacturer, the recycling process is to begin in spring 2023 and the product should still be available in 2023. A corresponding approval for the recycled desflurane is being planned for 2023 [28]. Recovery of 90 % of the absorbed anaesthetic gases is possible [28].

In a study at a German university hospital, only 25 % of the vapourised desflurane consumed could be reprocessed [30]. One explanation for this low rate could be that a large proportion of the anaesthetic gases are not exhaled until after extubation and are therefore not accessible to a filter system on the anaesthesia machine.[30] Leakage during ventilation can also lead to losses. In addition, a separate activated carbon filter was used for each patient in this study, which is not intended by the manufacturer.

In addition to the reduced emission of anaesthetic gases, the use of a filter system can offer a further advantage. If the anaesthesia machine is operated without AGSS when an anaesthetic gas absorber is used, this can lead to significant savings in compressed air. The provision of compressed air is an energy-intensive process with high electricity consumption. Studies at Essen University Hospital put the annual electricity consumption per AGSS connection at 11,738 kWh [31]. This corresponds to an annual emission of 5.7 t CO_2 equivalent per AGSS connection. In addition, not using the AGSS can lead to enormous cost savings [31].

When using an anaesthetic gas absorber, legal aspects must be taken into account. For example, the combination of two medical devices as in this case (anaesthesia machine with anaesthetic gas absorber) is not intended for by the manufacturer of the anaesthesia machine [28]. Furthermore, the operation of an anaesthesia machine with anaesthetic gases without AGSS and without a corresponding ready-to-use indicator is contrary to the DIN EN ISO 80601-2-13 [29,32]. Furthermore, in the field of occupational safety, the Technical Rules for Hazardous Substances apply, which aim to prevent contamination at the anaesthesia workplace [28]. Consequently, the use of the filter system requires a prior risk assessment by the user. Here, a national solution at the level of our professional society certainly seems to make sense.

Discussion

Anaesthetic gases belong to the group of halogenated hydrocarbons and have a relevant influence on greenhouse gas emissions in the health sector. The anaesthetic gas desflurane has extremely harmful effects on the climate. Various strategies, such as reducing fresh gas flow, using absorber systems or giving preference to TIVA, can improve the carbon footprint of anaesthesia.

Climate change is an all-encompassing problem for humanity. A consistent reduction of greenhouse gas emissions is necessary in the health sector and in all areas of life. This is the only way to mitigate the consequences of global warming. The German Medical Association also recognises this and calls for climate neutrality in the German health sector by 2030 [33].

Especially by avoiding desflurane, we anaesthetists can make a positive contribution to the climate. Corresponding demands are also being discussed politically at EU level. In a draft, the EU Commission proposes to ban desflurane as an anaesthetic gas from 2026 [29,34]. According to the proposal, desflurane may then only be used if its use is absolutely necessary and other anaesthetics cannot be administered for medical reasons. In addition, the exceptional use should be justified.

Due to the lower blood-gas partition coefficient and the resulting faster onset and withdrawal behaviour, patients can be expected to awaken earlier after general anaesthesia with desflurane (compared to sevoflurane). In fact, desflurane has repeatedly been shown to reduce the time to eye opening, time to extubation, time to obey commands and time to reorientation [35–37]. The use of desflurane not only results in a reduced time to extubation, but may also reduce the number of prolonged extubations (defined as a duration >15 min to extubation) [38]. Furthermore, pH and arterial CO_2 partial pressure normalise earlier after anaesthesia with desflurane [39]. In addition, patients can drink water earlier without having to cough [40]. One group that could particularly benefit from the pharmacological properties of desflurane are certainly the morbidly obese patients. In a meta-analysis from 2017, it was shown for patients after bariatric surgery that they opened their eyes 3.8 min earlier when using desflurane compared to sevoflurane and that the time to extubation could be reduced by 4.97 min [41]. Also, in this study, the Aldrete score on transfer to the recovery room was slightly higher in the desflurane group.

It can be assumed that in study situations the administration of the anaesthetic gas is terminated at a defined point in time (for example, at the end of the surgical measures) [39]. Earlier recovery when using desflurane is not particularly surprising due to the different pharmacological properties. In clinical practice with early adjustment of the depth of anaesthesia, this difference between sevoflurane and desflurane is expected to be of little relevance. It is also possible that the general anaesthetic approach has a greater influence on patient recovery than the choice of anaesthetic gas alone. Wider variables do not seem to depend on the choice between desflurane or sevoflurane. For example, whether patients are able to leave the recovery room sooner after inhaled anaesthesia with desflurane has not been established [35,36]. Nor does the incidence of postoperative cognitive dysfunction differ between the two anaesthetic gases [36].

Monitoring the depth of anaesthesia appears to be helpful. This can shorten the time until eye opening, reorientation and discharge from the recovery room [26]. Adapted and anticipatory anaesthetic management should then compensate for the pharmacological differences between desflurane and sevoflurane, so that no disadvantages for our patients or relevant delays in surgical planning are to be expected when sevoflurane is used. In the debate about the pros and cons of desflurane, the negative global consequences for the climate must ultimately be taken into account, which cannot be determined by looking at an individual patient or the surgical plan.

Furthermore, the question arises whether the direct atmospheric effects of anaesthetic gases can be avoided by other anaesthetic procedures. The use of propofol in the context of TIVA can significantly reduce greenhouse gas emissions during general anaesthesia. This could be shown in 2 life cycle analyses [20,21]. In these studies, the emissions of all steps from production, transport, application to disposal were summarised. Such calculations can contain inaccuracies and are dependent on local conditions – such as the type of electricity generation. Further studies, also from Germany, are necessary regarding this background. Even though the use of propofol involves other environmental risks, such as water pollution, it is recommended that propofol – if medically appropriate – be used in preference to anaesthetic gases [42]. It is important to mention here that about one third of propofol is discarded in clinics [43]. This is an unnecessary environmental burden and should be avoided as far as possible. This can be achieved, for example, by using smaller drug vials [43]. Careful and forward-looking planning also seems sensible here and can contribute to environmental protection. The advantages of TIVA with propofol include the lower incidence of postoperative nausea and higher patient satisfaction [44]. The administration of propofol can also lead to a shorter length of stay in the recovery room compared to anaesthetic gases [44].

Anaesthetic gas absorber systems are another way of controlling the negative effects of anaesthetic gases. The results of Hinterberg et al., in whose study only 25 % of the desflurane consumed could be recovered, are initially pessimistic [30], but they also mean 25 % less desflurane emission with a correspondingly less harmful effect on the climate. Strictly speaking, the proportion of absorbed desflurane could be higher, since only the recovered desflurane was determined in the study and not the captured desflurane. Although the use of desflurane in combination with an absorber system could save most emissions [30], it is unlikely that desflurane could achieve as low a greenhouse effect as sevoflurane. To do so, 98.5 % of desflurane would have to be captured (compared to sevoflurane without a filter) – due to its lower potency and greater global warming potential [45]. Anaesthetic gas absorber systems could consequently mitigate desflurane‘s climate-damaging effects if it absolutely had to be used. The filters can play a relevant role especially in combinations with sevoflurane. Using an absorber system, a fresh gas flow of 0.5 l/min and subsequent administration of the recycled sevoflurane, a carbon footprint equivalent to that of propofol can be achieved [21].

Regional anaesthesia procedures seem to make sense not only in terms of environmental impact and are therefore recommended in the position paper of the DGAI and BDA for avoiding inhalational anaesthesia [5]. In a study at a clinic in Australia, the CO_2 footprint of general anaesthesia was compared with that of spinal anaesthesia for total knee replacement [46]. If the procedure was performed under general anaesthesia (maintenance with sevoflurane or propofol), the CO_2 emissions were calculated to be 14.9 kg CO_2 equivalent. If spinal anaesthesia was used, the CO_2 footprint was 16.9 kg CO_2 equivalent. This result is initially surprising, as one would have expected lower emissions with spinal anaesthesia. On closer evaluation, this finding is put into perspective. In the study, all patients with spinal anaesthesia were sedated with propofol. This led to additional medication consumption. In addition, oxygen was administered to these patients (6–10 l/min). Oxygen consumption in the regional anaesthesia group was therefore significantly higher than in the general anaesthesia group, with a corresponding increase in energy consumption. Furthermore, the duration of anaesthesia was 39 min longer in the regional anaesthesia group, which also led to increased electricity and oxygen consumption. It was also remarkable that the authors of the study adapted their results to other regions. For the EU (greater share of electricity from alternative energy sources, less coal-fired power generation than in Australia), the CO_2 footprint for spinal anaesthesia was 9.9 kg CO_2 equivalent, for general anaesthesia one of 11.9 kg CO_2 equivalent – a result one would have rather expected.

This review shows that anaesthetic gases are a burden on the climate. In addition, various strategies and techniques for a more environmentally friendly anaesthesia were listed. Now it is up to us anaesthetists to take them to heart and integrate them into our daily work. In this way, we can make our contribution to a more sustainable health sector.

Abbreviations

AGSS	Anaesthetic Gas Flow System
GWP	Global Warming Potential
CO_2	Carbon Dioxide
CFC	Chlorofluorocarbon
HFC	Hydrofluorocarbons
CDE	CO_2 equivalent
MAC	Minimum Alveolar Concentration
DGAI	Deutsche Gesellschaft für Anästhesie und Intensivmedizin e. V.
BDA	Berufsverband deutscher Anästhesisten e. V.
TIVA	Total Intravenous Anesthesia

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