Observational Study

Medicine

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Reducing the carbon footprint of operating rooms through education on the effects of inhalation anesthetics on global warming

A retrospective study

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Abstract

Environmental concerns, especially global warming, have prompted efforts to reduce greenhouse gas emissions. Healthcare systems, including anesthesia practices, contribute to these emissions. Inhalation anesthetics have a significant environmental impact, with desflurane being the most concerning because of its high global warming potential. This study aimed to educate anesthesiologists on the environmental impact of inhalation anesthetics and assess changes in awareness and practice patterns, specifically reducing desflurane use. This study included data from patients who underwent surgery under general anesthesia 1 month before and after education on the effects of inhalation anesthetics on global warming. The primary endpoint was a change in inhalational anesthetic use. Secondary endpoints included changes in carbon dioxide equivalent (CO_2e) emissions, driving equivalent, and medical costs. After the education, desflurane use decreased by 50%, whereas sevoflurane use increased by 50%. This shift resulted in a reduction in the overall amount of inhalational anesthetics used. The total CO_2e and driving-equivalent values decreased significantly. The cost per anesthesia case decreased, albeit to a lesser extent than expected. Education on the environmental impact of inhalation anesthetics has successfully altered anesthesiologists' practice patterns, leading to reduced desflurane usage. This change has resulted in decreased CO_2e emissions and has had a positive effect on mitigating global warming. However, further research is required to assess the long-term impact of such education and the variability in practice patterns across different institutions.

Abbreviations: CO_2e = carbon dioxide equivalent, FGF = fresh gas flow, GHG = greenhouse gas, GWP100 = global warming potential 100, MAC = minimum alveolar concentration, N_2O = nitrous oxide.

Keywords: carbon footprint, desflurane, education, general anesthesia, global warming, inhalation anesthetics, sevoflurane

1. Introduction

Environmental issues are a global concern that must be addressed. Global warming is associated with greenhouse gas (GHG) emissions, and the contribution of healthcare systems to GHG emissions in developed countries ranges from 4% to 5%.[1] Regulations to reduce emissions of major GHGs, such as carbon dioxide, methane, and nitrous oxide (N_2O), have been increasingly strengthened; however, the medical industry has often disregarded these regulations because of medical necessity, and their contribution to GHG emissions and climate change has also been considered insignificant. However, over the past few decades, the environmental impact of inhalational anesthetics has increased, particularly with the increasing use of desflurane.[2] Recent studies have attempted to compare the relative environmental impacts of various anesthetics and minimize their carbon footprints. Inhalation anesthetics are chemical compounds that are inhaled through the lungs and ultimately act on the central nervous system to induce or maintain general anesthesia.[3] As inhalation anesthetics are known to have a significant impact on global warming, in 2022, the European Union officially declared that desflurane would be banned from 2026.[4] In addition, in 2022, the

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World Federation of Societies of Anesthesiologists published guidelines on the use of inhalation anesthetics to reduce atmospheric pollution.[5]

Only 5% of inhalation anesthetics are metabolized and eliminated from the patient body, and the remaining 95% are discharged through the scavenging system of the anesthetic machine and released into the atmosphere without additional post-processing.[6] GHG emissions other than CO_2 can be expressed by converting them into carbon dioxide equivalents (CO_2e), which is the standard means of assessing the carbon footprint and is defined as the amount of CO_2 emissions with the same global warming potential as other GHGs.[7] The global warming potential 100 (GWP100) is a number that indicates how much GHG affects a given gas compared to CO_2 over 100 years. Desflurane had the highest GWP100 at 2540, followed by isoflurane at 510, N_2O at 298, and sevoflurane at 130[8] indicating that 1 kg each of desflurane, N_2O, sevoflurane, and isoflurane could trap the same amount of heat as 2540, 510, 298, and 130 kg of CO_2, respectively. Among them, desflurane has the highest GWP100, which is believed to be due to its high minimum alveolar concentration (MAC), requiring use of a larger amount of gas than other gases. In contrast, N_2O and isoflurane have relatively low GWPs but can contribute to ozone layer depletion. In particular, N_2O has a long half-life of 114 years; therefore, it remains in the atmosphere for a long time and affects global warming.[8]

Desflurane and sevoflurane are commonly used inhalational anesthetics during surgery[9] However, the impact of inhalational anesthetics on global warming is not well known to clinicians, and there is a lack of research in this area. This study aimed to provide education to anesthesiologists regarding the impact of inhalation anesthetics on global warming and to assess the changes in awareness before and after this education. Additionally, we sought to determine whether education alone could reduce desflurane use by analyzing the changes in inhalation anesthetic use, CO_2e levels, and medical costs before and after education.

2. Materials and methods

2.1. Study design and patients

A specialist with over 10 years of experience provided approximately 30 minutes of face-to-face education on the impact of inhalation anesthetics on global warming to anesthesiologists (residents and specialists) at Pusan National University Yangsan Hospital and Pusan National University Hospital on October 27, 2022. In total, 38 individuals received education at both hospitals, with 20 participants at Pusan National University Yangsan Hospital and 18 at Pusan National University Hospital. Of these, 37 individuals responded to the post-education survey, 18 from Pusan National University Yangsan Hospital and 19 from Pusan National University Hospital. The survey was conducted on the day of the education through a Google link, and responses were accepted for up to 1 week after the education. The survey contents and results are attached as supplemental material (Supplemental Table 1, http://links.lww.com/MD/L645).

After educating anesthesiologists who work for Pusan National University Yangsan Hospital and Pusan National University Hospital about the impact of inhalation anesthetics on global warming, we analyzed the use of inhalation anesthetics and changes in CO_2e before and after education in actual clinical situations to determine whether education alone could reduce their use. A total of 4463 patients were included after Institutional Review Board approval from both hospitals (IRB No. 05-2023-067 and 2310-021-132). The clinical research was registered at ClinicalTrials.gov (Ref: NCT06084039) and conducted in accordance with the Helsinki Declaration 2013. This study included data from patients who underwent surgery under general anesthesia 1 month before (between September 27 and October 26, 2022) and after (October 28 and November 27, 2022) education on the effects of inhalation anesthetics on global warming. The exclusion criteria were as follows: surgery performed under regional anesthesia or total intravenous anesthesia; when the type of inhalation anesthetic was changed during surgery; short surgery within 1 hour; and anesthesia by an anesthesiologist who did not attend the education on the effects of inhalation anesthetics on global warming (Fig. 1).

2.2. Primary and secondary endpoints

The primary endpoint was to confirm the change in the type and amount of inhalational anesthetic used to maintain general anesthesia. It was calculated using the average value of the inhalation anesthetic concentration and fresh gas flow (FGF) rate during the entire anesthesia period, excluding the 15 minutes after the start of general anesthesia and 15 minutes before the end of anesthesia.

The secondary endpoint was to confirm the change in CO_2e, driving equivalent (equivalent driving distance and distance traveled by car to generate the same amount of GHGs), and medical costs incurred owing to the use of inhalation anesthetics. Based on data from medical records, CO2e, driving equivalents, and medical costs incurred due to inhalation anesthetics were calculated using an anesthesia cost calculator (https://jscalc.io/calc/do45BOJVrzXMaEGC).

2.3. Statistical analysis

Continuous variables were examined for normality using the Shapiro—Wilk test. Normally distributed variables were compared using Student *t* test, whereas non-normally distributed variables were compared using the Mann—Whitney U test. Numerical results were expressed as mean ± standard deviation or median (interquartile range), as appropriate. Categorical variables were summarized by frequency and percentage and examined using the chi-square or Fisher exact tests. For data visualization, bar and pie charts were also displayed. All statistical analyses were performed using the Statistical Package for the (version 26.0; IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp) *P* values < .05 were considered statistically significant.

3. Results

3.1. Survey for attending anesthesiologists

Nearly half of the respondents said that they had learned about the global warming potential of general anesthetics for the first time through this lecture. Before the lecture, 78.4% of the participants frequently used desflurane to maintain general anesthesia. When asked which anesthetic agent was most frequently used during general anesthesia, 67.6% of the participants answered that desflurane was used, whereas 32.4% reported using sevoflurane. After education, when asked about their choice of anesthetic agent for future use during general anesthesia, 91.9% answered that they would use sevoflurane. Even if multiple choices of answers were not allowed for this question, 72.3% answered that they would use sevoflurane (Fig. 2 and Supplemental Table 1, http://links.lww.com/MD/L645).

3.2. Patient characteristics

During the study period, 4463 patients underwent general anesthesia. Of these, 1620 underwent regional anesthesia, total intravenous anesthesia, or experienced a change in the type of inhalation anesthetic during surgery and were excluded from the analysis. Additionally, short surgeries lasting <1 hour (n = 664) and cases in which anesthesia was administered by

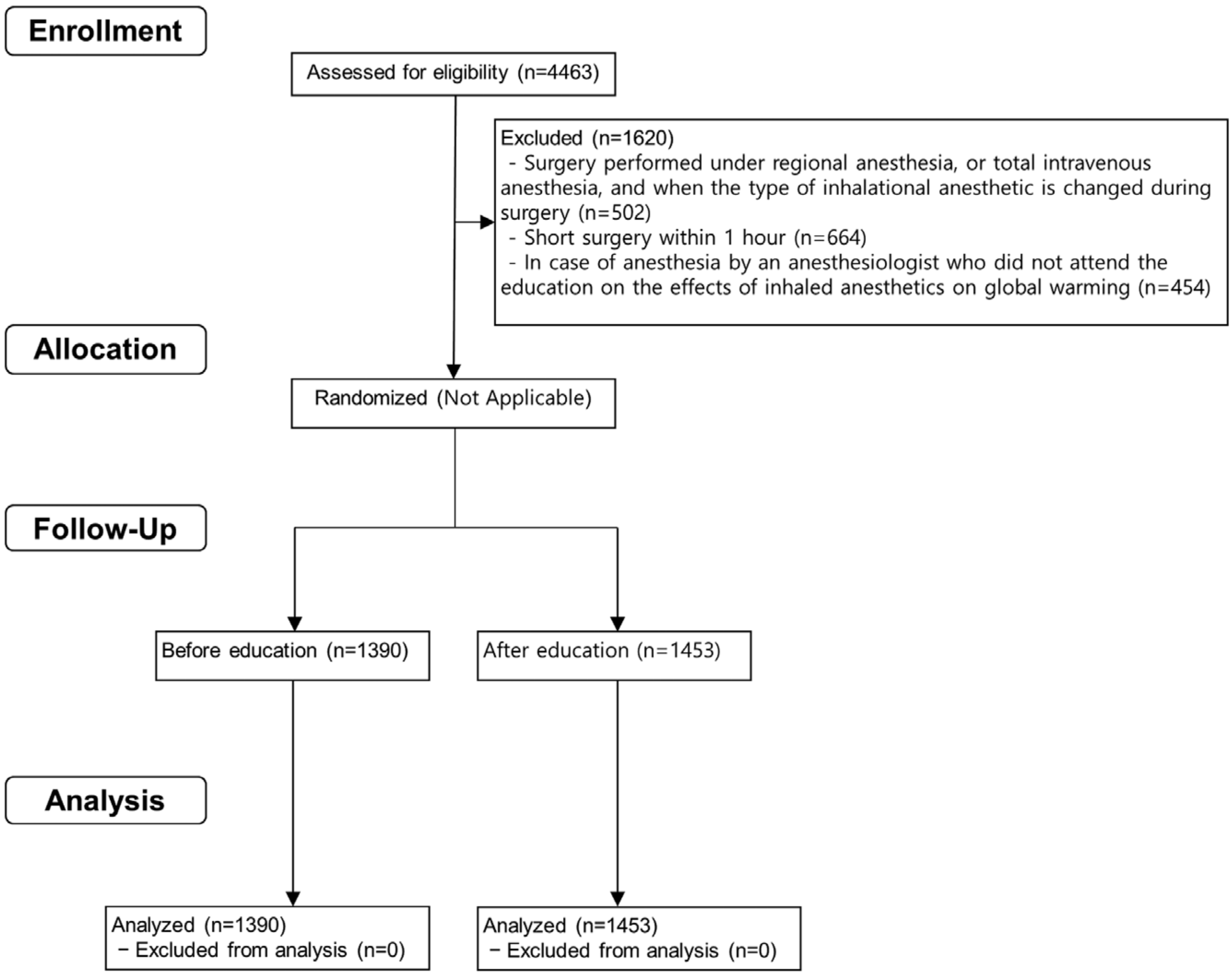

Figure 1. Consort flow. During the study period, 4463 patients underwent general anesthesia. Of these, 1620 underwent regional anesthesia, total intravenous anesthesia, or experienced a change in the type of inhalation anesthetic during surgery and were excluded from the analysis. Additionally, short surgeries lasting <1 h (n = 664), and cases in which anesthesia was administered by an anesthesiologist who did not attend the education on the effects of inhalation anesthetics on global warming (n = 454) were excluded from the analysis. A total of 1390 patients before and 1453 patients after education were included in this study.

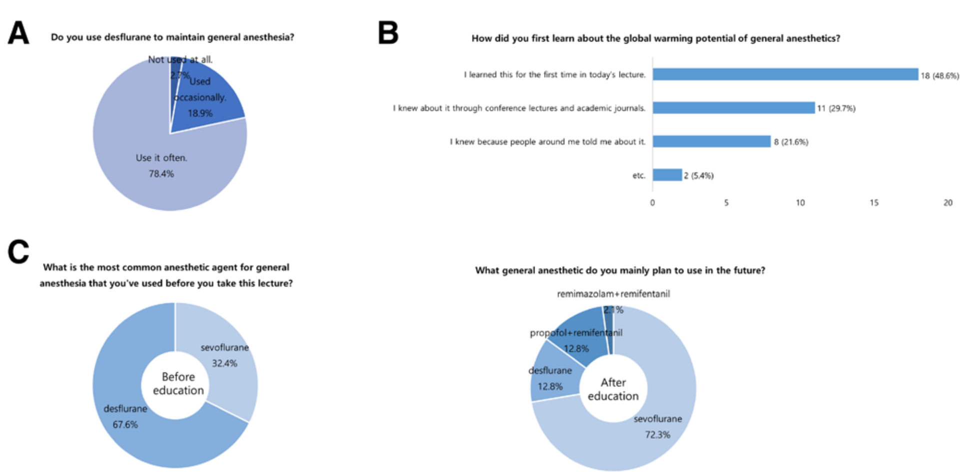

Figure 2. The result of survey after education for anesthesiologists about the impact of inhalation anesthetics on global warming. (A) Before the lecture, 78.4% of the members frequently used desflurane for maintaining general anesthesia. (B) Nearly half of the respondents said that they had learned about the global warming potential of general anesthetics for the first time through this lecture. (C) When asked which anesthetic agent you most frequently used during general anesthesia, 67.6% of the participants answered that it was desflurane, while 32.4% reported using sevoflurane. After the education, when asked about their choice of anesthetic agent for future use during general anesthesia, 91.9% of them answered that they would use sevoflurane.

an anesthesiologist who did not attend the education on the effects of inhalation anesthetics on global warming (n = 454) were excluded from the analysis. A total of 1390 patients before and 1453 patients after education were included in this study (Fig. 1). Patient characteristics are presented in Table 1.

3.3. Primary and secondary outcomes

Changes in the use of inhalation anesthetics, CO_2e, and medical costs before and after education of anesthesiologists are presented in Table 2. Compared to before education, the frequency of use of sevoflurane after education increased by 50% from 39.7 to 59.8%, and the frequency of use of desflurane decreased by 50% from 60.3 to 40.2% ($P < .001$). The results show that after the education, the volume of sevoflurane used per surgery performed under general anesthesia increased from 14.9 ± 25.3 to 21.6 ± 28.2 mL ($P < .001$), while the volume of desflurane used decreased from 49.1 ± 62.7 to 32.9 ± 50.9 mL ($P < .001$), resulting in an overall decrease in the amount of anesthetic gas used. However, there was no significant difference in the FGF rates before and after education.

CO_2e per surgery performed under general anesthesia increased from 2.9 ± 5.0 to 4.2 ± 5.5 kg for sevoflurane ($P < .001$), while desflurane decreased from 182.7 ± 233.4 to 122.2 ± 189.3 kg ($P < .001$), resulting in a decrease in total CO_2e. The driving equivalent per surgery performed under general anesthesia showed a slight increase in sevoflurane, but the decrease in desflurane was large; the driving equivalent of total anesthetics decreased significantly from 727.9 ± 906.6 km before education to 496.0 ± 732.1 km after education ($P < .001$). Total anesthetic cost per surgery performed under general anesthesia also decreased from $14.6 ± 12.6 to $ 12.4 ± 10.0 ($P < .001$).

4. Discussion

In this study, it was observed that after education on the impact of inhalational anesthetics on global warming, the use of desflurane decreased, and the use of sevoflurane increased during general anesthesia. Furthermore, after education, both CO_2e emissions and driving equivalents decreased.

Desflurane has lower potency than other inhalation anesthetics, but it has an exceptionally low blood/gas partition coefficient. This low partition coefficient results in rapid induction and emergence from anesthesia. Because of these advantages, desflurane is preferred for general anesthesia. Evidence suggests that desflurane results in a recovery time that is 1 to 2 minutes faster than that of sevoflurane. When using desflurane for a 3-h surgery, it has been reported that the average time to obey commands is reduced by 1.7 minutes, and extubation is reduced by 1.3 minutes compared to when sevoflurane is used. However, there was no difference in discharge time from the post-anesthesia care unit between the 2 anesthetic gases.[10] As the duration of surgery increases, the advantages of desflurane in terms of faster recovery time become more pronounced than those of other inhalation anesthetics. The context-sensitive decrement time for inhalation anesthetics is affected by the duration of anesthesia and the time required to decrease the alveolar or vital tissue concentration. Owing to its relatively low solubility, desflurane exhibits minimal delayed arousal effects compared to other anesthetics, even when the duration of anesthesia is extended.[11] In clinical practice, it is common to taper the administration of inhalation anesthetics toward the end of surgery; therefore, the difference in wake-up time between anesthetics is not significant. The preference for and frequent use of desflurane is likely rooted in the habits and practices of anesthesiologists.

The survey revealed that half of the respondents were aware of the global warming potential of general anesthetics, but 67.6% said they usually used desflurane during general anesthesia, which was twice the number of respondents who said they used sevoflurane. However, after the educational program, there was a significant shift in preferences. Of the respondents, 91.9% indicated that they would use sevoflurane, and there was an increase in respondents who opted for total intravenous anesthesia using propofol or remimazolam instead of desflurane. This suggests that education has a notable impact on changing awareness and practice patterns regarding the environmental impacts of inhaled anesthetics.

In the literature referenced prior to this study, desflurane use decreased from 8.3% to 2.9% after sustainability education. However, the anesthesiologists did not stop at this point but further reduced desflurane usage to as low as 0.3% by physically removing the desflurane vaporizer from the anesthesia machine. The study found that although desflurane use significantly decreased after education, it was concluded that sustainability education alone was not as effective as restrictions on vaporizer use.[12] However, we could not conduct research by removing desflurane from the vaporizers. Despite this limitation, this study effectively assessed the extent to which inhalation anesthetics contribute to global warming by examining factors such as CO_2e and driving equivalent values. Removal of the vaporizer is possible after reaching a consensus through adequate education. This was a one-time pre- and post-education study. It would likely be more effective to provide ongoing education rather than just a single session. This is because, in the initial survey with allowed multiple choices of answer, 91.9% indicated that they would use sevoflurane, but ultimately they did not. In other words, many anesthesiologists initially switched to sevoflurane briefly and then reverted to their original practice. Therefore, regular education is necessary to prevent this.

In fact, after education, the amount of desflurane used during anesthesia decreased. Instead, although the amount of sevoflurane used increased, the total amount of inhalation anesthetic used decreased from 64.0 to 54.4 mL. This can be explained by the difference in the MAC of the inhalation anesthetics. The MAC represents the concentration of the anesthetic within the alveoli that prevents movement in response to standard stimuli,

Table 1

Patients' characteristics.

	Before education (n = 1390)	After education (n = 1453)	*P* value
Age (yr)	52.4 ± 22.5	54.7 ± 21.6	.008*
Male	685 (49.3)	779 (53.6)	.021*
Female	705 (50.7)	674 (46.4)	
Height (cm)	157.4 ± 21.6	158.5 ± 20.2	.349
Weight (kg)	60.6 ± 18.2	61.5 ± 17.6	.143
BMI (kg/m^2)	23.6 ± 4.3	23.7 ± 4.3	.298
ASA class			.012*
I	307 (22.1)	266 (18.3)	
II	726 (52.2)	826 (56.8)	
III	333 (24.0)	326 (22.4)	
IV	22 (1.6)	25 (1.7)	
V	2 (0.1)	9 (0.6)	
VI	0 (0.0)	1 (0.1)	
Co-morbidity			
Hypertension	431 (31.0)	471 (32.4)	.420
Diabetes	224 (16.1)	238 (16.4)	.848
CKD	77 (5.5)	62 (4.3)	.116
Stroke	58 (4.2)	55 (3.8)	.597
CHF	30 (2.2)	16 (1.1)	.026*
COPD	36 (2.6)	46 (3.2)	.359

Values are presented as mean ± standard deviation or number (proportion).
* Statistical significance; ASA = American Society of Anesthesiologists, BMI = body mass index, CHF = congestive heart failure, CKD = chronic kidney disease, COPD = chronic obstructive pulmonary disease.

Table 2

Changes in inhalation anesthetic use, CO_2e, and medical costs before and after education for anesthesiologists about the impact of inhalation anesthetics on global warming.

	Before education (n = 1390)	After education (n = 1453)	*P* value
Attending anesthesiologist			.016*
1 (1st and 2nd yr residents)	425 (30.6)	501 (34.5)	
2 (3rd and 4th yr residents)	409 (29.4)	444 (30.6)	
3 (Specialist <10 yr)	423 (30.4)	368 (25.3)	
4 (Specialist for over 10 yr)	133 (9.6)	140 (9.6)	
Incidence of use			
Sevoflurane	552 (39.7)	869 (59.8)	<.001*
Desflurane	838 (60.3)	584 (40.2)	
Use of N_2O	11 (0.8)	7 (0.5)	.298
Duration of anesthesia (h)	2.6 ± 1.7	2.6 ± 1.6	.887
Mean vol%	4.2 ± 2.0	3.4 ± 2.0	<.001*
Mean FGF rate (L/min)	2.2 ± 0.5	2.2 ± 0.4	.758
Volume of used inhalation anesthetics (mL)	14.9 ± 25.3	21.6 ± 28.2	<.001*
Sevoflurane	49.1 ± 62.7	32.9 ± 50.9	<.001*
Desflurane	64.0 ± 55.7	54.4 ± 44.4	<.001*
Total			
CO_2 equivalent (kg)			
Sevoflurane	2.9 ± 5.0	4.2 ± 5.5	<.001*
Desflurane	182.7 ± 233.4	122.2 ± 189.3	<.001*
Total	185.6 ± 231.2	126.5 ± 186.7	<.001*
Driving equivalent (km)			
Sevoflurane	11.6 ± 19.6	16.6 ± 21.5	<.001*
Desflurane	716.4 ± 915.5	479.4 ± 742.6	<.001*
Total	727.9 ± 906.6	496.0 ± 732.1	<.001*
Anesthetic cost ($)			
Sevoflurane	3.5 ± 5.9	5.0 ± 6.6	<.001*
Desflurane	11.1 ± 14.2	7.4 ± 11.5	<.001*
Total	14.6 ± 12.6	12.4 ± 10.0	<.001*

Values are presented as mean ± standard deviation or number (proportion).

* Statistical significance.

$ = United States currency, CO_2e = carbon dioxide equivalent, FGF = fresh gas flow, N_2O = nitrous oxide.

such as surgical incisions, in 50% of patients. This is used to indicate the relative potency of the inhalational anesthetics. Desflurane and sevoflurane concentrations equivalent to 1 MAC (% atm/mm Hg) were 6 and 2 vol%, respectively.[13,14] In other words, because sevoflurane has a lower MAC value than desflurane for achieving the same depth of anesthesia, the volume of inhalational anesthetic required is lower. Therefore, the overall use of inhalational anesthetics has decreased. This change indicates a reduction in the overall use of inhalational anesthetics, which aligns with the goal to mitigate their environmental impact.

In this study, one approach to reduce GHG emissions from inhalation anesthetics was to provide education on low-flow anesthesia using an oxygen/air mixture at a flow rate of <1 L/min. However, the results indicated that there was no change in the FGF before and after education. There are concerns that a substance called compound A, which is produced when sevoflurane is used at low FGF, may cause renal injury. Owing to these concerns, the United States Food and Drug Administration recommends a minimum FGF rate of 2 L/min.[15] However, there is no clinical evidence of the harm caused by compound A in humans at low FGF rates. Therefore, sevoflurane at a low FGF rate may be safe,[16,17] suggesting that sustainability education on low-flow anesthesia may not have had a significant impact on the FGF in this context.

The healthcare system accounts for approximately 5% of total global GHG emissions, a proportion that is roughly similar to the emissions produced by harmful air pollutants.[1,18] Inhalation anesthetics contribute to approximately 0.01% to 0.1% of the total CO_2e emissions associated with global warming.[8,19] While this percentage may seem small globally, CO_2e emissions from inhalation anesthetics account for 5% of a hospital CO_2e and 50% of surgery-related CO_2e.[20–22] Therefore, anesthesiologists play an important role in reducing the environmental impact through their care. The annual number of major surgeries worldwide in which general anesthesia using inhalation anesthetics is performed is approximately 200 million, and global emissions of inhalation anesthetics are equivalent to emissions of approximately 4.4 million tons of carbon dioxide.[23] Global emissions of inhalation anesthetics could contribute to a climate change effect similar to carbon dioxide emissions from approximately 1 million passenger cars, measured at GWP100[24] because passenger vehicles in the United States emit approximately 5.03 tons of carbon dioxide per year.[25] Considering that the number of general anesthesia cases performed in South Korea is 1.0 to 1.2 million,[26] and if the use of desflurane accounts for about 1/5 as reported in the United States or Europe,[27,28] and the results of our study are applied, a reduction in CO_2 emissions of 20,000 to 24,000 tons per year in South Korea can be expected. When applied to global emissions from inhalation anesthetics, a mathematical reduction of 4.0 million tons of CO_2 emissions can be expected, which is equivalent to the CO_2e of driving 800,000 cars.

When the anesthetic gas was administered at a steady state of 2 L/min for 6 hours, the amount of CO_2 emitted, converted to the distance driven by a car, was equivalent to approximately 77 km for sevoflurane and 3650 km for desflurane. Desflurane emits CO_2 about 50 times more than sevoflurane, and the amount increases further with FGF.[29] The results presented in Figure 3 demonstrate a significant reduction in CO_2 emissions from inhalational anesthetics. This reduction was achieved by decreasing the dose of desflurane and increasing the dose of sevoflurane. Current guidelines emphasize the reduction of desflurane usage as a key focus in efforts to mitigate the environmental impact of inhaled anesthetics. There was a reduction in the cost of approximately $2 per anesthesia case. Although this is a statistically significant reduction, it is not as large as expected as a cost reduction of $600,000 to $720,000 per year, even considering the number of general anesthesia cases and the amount of desflurane used in South Korea.

This study had several limitations. First, not all team members participated in education. Of 150 anesthesiologists, 13 did not participate in education. Consequently, the data analysis excluded the number of cases of anesthesia administered by those who did not complete the education. Among all anesthesia cases 1 month before and after education, 242 out of 1632 people were excluded before education, and data for 212 out of 1453 people after education were not included. Second, this study was conducted by anesthesiologists at 2 hospitals, and the results may lead to different outcomes if the trainees' characteristics change as education is conducted in different regions and institutions. Third, the healthcare system generates CO_2e through various pathways.[30] However, this study focused on education and analysis of inhalation anesthetics, excluding other sources. Although N_2O has a relatively low GWP, it destroys the ozone layer and has a long half-life of 114 years. Therefore, it remains in the atmosphere for a long time and contributes to global warming.[8] However, N_2O is typically used in specific, limited circumstances to reduce the concentration of other inhalation anesthetics administered to patients rather than as a stand-alone anesthetic agent.[31] Therefore, it was difficult to confirm N_2O use during general anesthesia using retrospective data analysis in this study. Anesthesia is often adjusted by changing the concentration and flow rate of inhalational anesthetics to achieve the desired level. Additionally, administering analgesics for pain control during surgery can affect general anesthetics. However, the data could not be analyzed in detail to reflect the changes in usage patterns and flow rates. Fourth, the analysis focused on the 1-month period immediately following education, during which conscious efforts would be made to use sevoflurane instead of desflurane. However, the study did not investigate whether the effects of education continued over time or whether there were changes in the choice of anesthetics over time. Therefore, it is necessary to examine the long-term impacts of education through follow-up studies. Finally, because this was an observational study and not a randomized controlled study confirming the use patterns of inhalation anesthetics according to the anesthesiologist education, the effect of education could not be observed.

5. Conclusion

In conclusion, educating anesthesiologists on the environmental impact of inhalation anesthetics alone was effective in reducing the use of desflurane, leading to a decrease in CO_2e and driving equivalent values. This suggests the positive effect of mitigating global warming. However, it is essential to recognize that healthcare systems generate CO_2e emissions through various pathways and that the characteristics of trainees can vary from one institution to another. Further studies are required to assess this more comprehensively.

Author contributions

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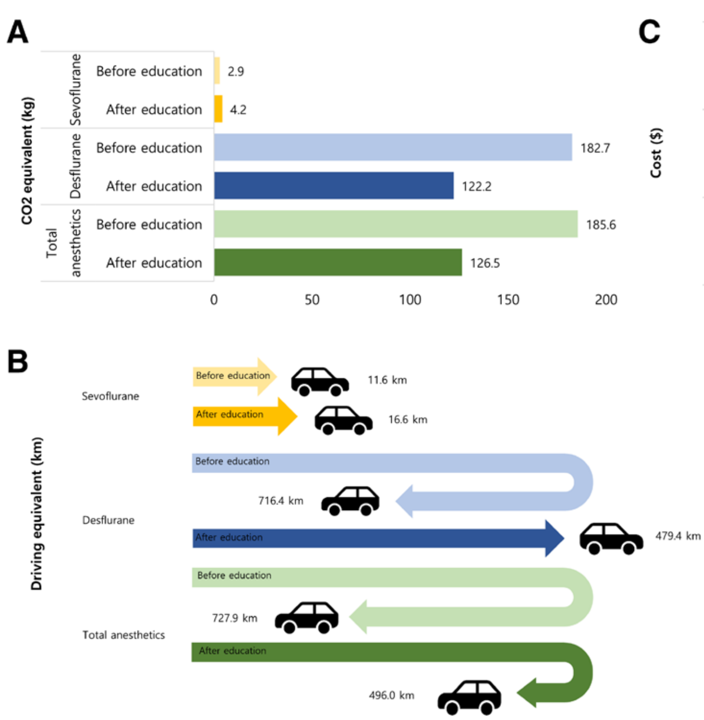

Figure 3. Changes in CO_2e, driving equivalent, and medical costs before and after education. CO_2e, carbon dioxide equivalent. (A) Compared to before education, after education CO_2e per surgery performed under general anesthesia increased from 2.9 ± 5.0 to 4.2 ± 5.5 kg for sevoflurane ($P < .001$), while desflurane decreased from 182.7 ± 233.4 to 122.2 ± 189.3 kg ($P < .001$), resulting in a decrease in total CO_2e. (B) The driving equivalent per surgery performed under general anesthesia showed a slight increase in sevoflurane but the decrease in desflurane was large, the driving equivalent of total anesthetics decreased significantly from 727.9 ± 906.6 km before education to 496.0 ± 732.1 km after education ($P < .001$). (C) Total anesthetic cost per surgery performed under general anesthesia also decreased from $14.6 ± 12.6 to $ 12.4 ± 10.0 ($P < .001$). CO2e = carbon dioxide equivalent.

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