How green is my operation theater?

Nishant Kumar,
Ranju Singh, Aruna Jain,
Abhijit Bhattacharya

Department of Anaesthesia, Pain and Critical Care, Lady Hardinge Medical College and Associated Hospitals, New Delhi, 1Department of Anaesthesia and Pain, Samvedna Pain Hospital, Noida, Uttar Pradesh, India

ABSTRACT

Objective: To ascertain the awareness regarding global warming and the anesthesia practices contributing to it in the city of Delhi. Materials and Methods: A questionnaire was circulated amongst the qualified anesthesiologists (consultants and senior residents) in the city of Delhi. The initial contact was made through e-mail and the questionnaire was required to be filled and returned electronically. The questionnaire was also made available online at http://sites.google.com/site/surveydelhi. After 1 month, the forms were distributed physically. Assuming that at least 50% of the approximately 1200 practising anesthesiologists would be able to recognize the greenhouse gases correctly, the target number of responses was 150 with 99% confidence limit. Results: Of the 831 anesthesiologists contacted, only 184 responded. Ninety-eight percent were aware of the greenhouse effect, but only 15.8% (29) could correctly identify all the greenhouse gases. However, 47.28% (87) could identify nitrous oxide and inhalational agents as a cause of greenhouse effect. Ninety percent of the respondents use circle system and 87% use low flows frequently. Ninety-three percent (171) of respondents routinely use nitrous oxide, and 32.1% (59) would, however, not use air even if made available. Seventy-nine percent (145) advocated total intravenous anesthesia as an alternative to reduce the menace. Conclusion: Only 22% were motivated enough to respond to the survey. More than half of these anesthesiologists were not aware about the anesthetic agents contributing to the greenhouse effect. However, their clinical practices inadvertently do not add to the environmental pollution.

Key words: Environment, greenhouse effect, survey, volatile anesthetics

INTRODUCTION

There is an increasing concern about pollution of the atmosphere due to human activities. Whether it is the traffic spewing exhaust fumes or the stench that emanates from once upon a time river along the city! It is either too hot or too cold. Experts call it global warming, owing to the greenhouse effect.

All the volatile anesthetics that are currently used (halothane, isoflurane, enfurane, sevoflurane, and desflurane) are halogenated compounds potentially destructive to the ozone layer. The widely used anesthetic gas nitrous oxide (N₂O) is an established greenhouse gas. A recent report suggests that N₂O is also an important ozone-depleting gas. Anesthesiologists are thus equal contributors, thanks to the widespread use of these gases.

We designed a simple questionnaire to help us estimate the awareness regarding this issue and anesthesia practices in the National Capital Territory of Delhi (India) and the measures undertaken to reduce harmful effects of anesthetic gases on climate.

MATERIALS AND METHODS

After obtaining approval from the Research and Protocols Committee, a questionnaire (Appendix) containing 19 items was circulated amongst the qualified anesthesiologists in the city of Delhi. The questionnaire included awareness regarding greenhouse effect, gases responsible, facilities available in their setup, and anesthesia practices that can have an impact on countering this menace. The list and e-mail addresses of the practising anesthesiologists were obtained from the Indian Society of Anaesthesiologists (Delhi branch) website (www.isadelhi.com). The initial contact was made through e-mail, and the questionnaire was sent as an attachment which was required to be filled and returned electronically. The questionnaire was also
APPENDIX *Required

1. Number of operating tables in the hospital*
   a. 2  b. 3-5  c. 6-10  d. 11-20  e. >20
2. Number of operating tables you are responsible for*
   a. 1  b. 2  c. 3  d. 4  e. >4
3. Are you aware of the greenhouse effect?*
   a. Yes  b. No
4. Greenhouse effect is related to* (more than one option)
   a. CO₂  b. N₂O  c. CH₄  d. Halogenated inhalational agents  e. CFC
5. Do you have laminar air flows in the OTs?*
   a. Yes  b. No
6. Do you have a scavenging system?*
   a. Yes  b. No
7. If yes, whether¼
   a. Active  b. Passive
8. Which type of breathing circuit do you use?*
   a. Bain's (semi-open)  b. Circle (closed)  c. Any other
9. If closed circuit, how often?
   a. Always  b. Frequently  c. Occasionally  d. Rarely  e. Never
10. Do you use low gas flows?
    a. Yes  b. No
11. How much flow do you usually use?*
    a. >4 l/min  b. 2-4 l/min  c. 1-2 l/min  d. <1 l/min
12. How often do you use low gas flows?
    a. Always  b. Frequently  c. Occasionally  d. Rarely  e. Never
13. You routinely use...*
    a. N₂O  b. Air
14. How often do you use air?
    a. Always  b. Frequently  c. Occasionally  d. Rarely  e. Never
15. You do not use air because¼
    a. Not available  b. Increased requirement of opioids  c. Not comfortable
16. If air was available in your theater, would you prefer it over nitrous oxide?*
    a. Yes  b. No
17. Which agent do you think contributes the most to the greenhouse effect?*
    a. Nitrous oxide  b. Halothane  c. Isoflurane  d. Desflurane  e. Sevoflurane
18. General anesthetic technique which can minimize greenhouse effect¼*
19. How often do you use TIVA?*
    a. Always  b. Frequently  c. Occasionally  d. Rarely  e. Never

made available on the website http://sites.google.com/site/surveydelhi. A period of 1 month was allotted for online submission. After this time period, the forms were distributed physically in various hospitals to target anesthesiologists who had not participated online. All information that was provided remained confidential. At no point was anyone asked to disclose his/her identity. Data collected included the percentage of anesthesiologists correctly identifying greenhouse gases (GHG), preferring air over N₂O, using closed circuit and low to very low flows, and using total intravenous anesthesia (TIVA).

Statistical analysis
Sample size was calculated using OpenEpi, Version 2, open source calculator (SSPropor: http://www.openepi.com/OE2.3/SampleSize/SSPropor.htm). There are approximately 1200 practising anesthesiologists in Delhi. Assuming that 50% (±10%) of the anesthesiologists will correctly identify the GHG, a sample size of 146 participants was required with confidence limits of 99% and a design effect of 1.0. We aimed to include at least 150 anesthesiologists. Data collected and analyzed included percentage of participants correctly identifying GHG, and using air, closed circuit, low to very low flows, and TIVA. Chi-square test was used for analysis and a $P < 0.05$ was taken as significant.

RESULTS

Of the 831 anesthesiologists contacted, only 184 (22.14%) responded. Ninety-eight percent were aware of the greenhouse effect, but only 29 (15.8%) could correctly identify all the GHG. However, amongst the gases which concern us, 40 (21.7%) respondents could identify only N₂O, 27 (14.7%) only inhalational agents, and 87 (47.28%) could identify both as a cause of greenhouse effect. Only 18.5% could recognize desflurane as the gas with maximum
greenhouse warming potential (GWP). Ninety percent of the respondents use circle system and 87% use low flows frequently. Hundred and seventy-one (92.9%) of the respondents routinely use N₂O. Fifty-nine (32.1%) would, however, not prefer air even if it made available to them. One hundred and forty-five anesthesiologists (78.8%) advocated TIVA as an alternative to reduce the menace. The results are depicted in Table 1.

### DISCUSSION

Industrialization and human development in the last 100 years has led to an increase in concentration of GHG in the atmosphere and an increase in mean surface temperature of the earth.[1] The major long-lived GHG include CO₂, CH₄, N₂O, and halogenated organic compounds. The destructive potential of chlorofluorocarbons (CFC) and

| Table 1: Responses to the questionnaire |
|----------------------------------------|
| **Question** | **Number of respondents** | **Responses** | **P value** |
| --- | --- | --- | --- |
| Number of operating tables in the hospital | 184 | 2 | 6-10 | <0.01 |
| | | 13 (7.1%) | 50 (27.2%)* | |
| | | 3 | 67 (36.4%)* | |
| | | 5 (2.7%) | 23 (12.5%) | |
| | | >20 | 4 | |
| Number of tables you are responsible for | 184 | 98 (53.3%)* | 114 (61.95%) | |
| | | 1 | 117 (69.02%) | |
| | | 2 | 127 (70.92%) | |
| | | 54 (29.3%) | 3 | |
| | | 181 (98.4%)* | 179 (98.05%) | |
| Are you aware of greenhouse effect? | 184 | CO₂, N₂O, CH₄, inhalational agents, CFC | Inhalational agents and/or other gases | <0.01 |
| | | N₂O alone and/or other gases | N₂O+inhalational agents and/or other gases | |
| | | 114 (61.95%) | 87 (47.28%) | |
| | | Yes | No | |
| | | 127 (69.02%) | 117 (69.02%) | |
| | | No | No | |
| | | 125 (67.9%) | 3 | |
| | | 87 (47.3%) | 97 (52.7%) | |
| | | 59 (32.1%) | 125 (67.9%)* | |
| | | 26 (14.1%) | Passive | |
| | | 13 (7.1%) | Circle (closed) | |
| | | Any other | 165 (89.7%)* | |
| | | 77 (41.8%) | Occasionally | |
| | | 19 (10.3%) | 3 (1.6%) | |
| | | 169 (91.8%)* | No | |
| | | 15 (8.2%) | 10 (5.4%) | |
| | | >4 l/min | 1-2 l/min | |
| | | 2-4 l/min | <1 l/min | |
| | | 13 (7.1%) | 114 (62.0%)* | |
| | | 37 (20.1%) | 20 (10.9%) | |
| | | 114 (62.0%)* | Occasionally | |
| | | 37 (20.1%) | 12 (6.5%) | |
| | | 31 (16.8%) | Rarely | |
| | | 89 (48.4%)* | Never | |
| | | 13 (7.1%) | Passive | |
| | | 12 (6.5%) | 5 (2.7%) | |
| | | | Rarely | |
| | | | Never | |
| | | | 89 (48.4%)* | |
| | | | 31 (16.8%) | |
| | | | 2 (1%) | |
| | | | 37 (20.1%) | |
| | | | 37 (20.1%) | |
| | | | 89 (48.4%)* | |
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| | | | 31 (16.8%) | |
halons (halothane, enflurane, isoflurane, desflurane, and sevoflurane) has been discussed for many years,\cite{10,11} but has become obvious since 1985 after the discovery of ozone hole in Antarctica.\cite{16} The medical consumption of CFC corresponds to approximately 1% of the total CFC consumption and is mainly used as propellant in pulmonary medicine.\cite{10} A widely used anesthetic, N\textsubscript{2}O, is an established GHG and an important ozone-depleting gas.\cite{12-4} While 98.4% of the respondents were aware of the greenhouse effect, only 15.8% of the anesthesiologists could identify all the GHG. However, amongst the gases which concern us, 40 (21.7%) respondents could identify only N\textsubscript{2}O, 27 (14.7%) only inhalational agents, and 87 (47.28%) could identify both as a cause of greenhouse effect.

N\textsubscript{2}O remains in the atmosphere for around 150 years and atmospheric lifetimes range between 1.4 and 21.4 years for sevoflurane and desflurane, respectively.\cite{10,11} Emissions of gases is conventionally placed on a CO\textsubscript{2}-equivalent scale, the chosen metric being the GWP.\cite{12} Thus, GWP is a measure of how much a given mass of greenhouse gas contributes to global warming over a specified time period.\cite{13} N\textsubscript{2}O, as a carrier gas for other halogenated agents or as a supplemental anesthetic with intravenous drugs, contributes to around 0.1% of the climate effect,\cite{14} whereas halogenated compounds (isoflurane, desflurane, and sevoflurane) contribute to only 0.02%\cite{15}. Thus, the main concern should be the use of N\textsubscript{2}O since it is much more widely used than desflurane and in higher quantities. In fact, 1% of the human production of N\textsubscript{2}O is due to its use in clinical anesthesia.\cite{16} It is used by 92.9% of the respondents routinely. Thirty-two percent of the respondents would, however, not prefer to use air even if it was made available to them. Twelve percent of the respondents were not comfortable, whereas 20.1% felt that requirement of opioids would increase and thus they continue using N\textsubscript{2}O.

If we consider the GWP of these gases over a 20-year (GWP\textsubscript{20}) and 100-year (GWP\textsubscript{100}) period, we find that GWP of N\textsubscript{2}O is 289 and 298, respectively.\cite{14} Desflurane with a lifetime of 10 years\cite{14} has a GWP\textsubscript{20} of 3714, as compared to 1980 of sevoflurane and 1401 of isoflurane.\cite{14} Despite desflurane being more of a threat to the atmosphere, only 18.5% anesthesiologists recognized it.

Eighty percent of the halogenated anesthetic agents are eliminated through exhalation without being metabolized in the body. Most commonly used anesthesia systems discharge these expired gases directly to the atmosphere, thus polluting the operating suites, and contribute to greenhouse effect due to their longevity. Scavenging systems reduce the spillage in the operating rooms, but eventually the gases are exhausted into the atmosphere.\cite{18} Only 32.1% of the respondents had access to scavenging systems. The consumption of inhaled anesthetics can be reduced by 80-90% if closed circuits are used, especially if “low flow” anesthesia is used along with them. Approximately 92% of the anesthesiologists in our survey use closed circuits and low flows frequently. However, only 72.9% used flows of <2 l/min. The flows assume importance since a higher flow implies a higher concentration in the atmosphere.\cite{15}

The alternatives to minimize the greenhouse effect of inhaled anesthetics include use of TIVA as advocated by 78.8%, low flows (20.6%), scavenging (6%), air (4.9%), and xenon (1%). While TIVA precludes the use of all inhaled anesthetics, including N\textsubscript{2}O, using low flows will minimize the consumption of inhalational anesthetics. This, however, is not without environmental costs. Exclusive use of TIVA will require use of plastic syringes and tubings which increase mounds of slow degradable/non-degradable plastic waste. Although 72% of the respondents use TIVA occasionally, only 37.5% of the respondents have access to air. This implies that either they use 100% oxygen or TIVA has been misinterpreted to exclude only the halogen anesthetics. Scavenging, as suggested by 6%, may reduce operating room pollution, but ultimately the gases are released in the atmosphere unless an anesthetic-conserving device utilizing the principle of zeolite filter is incorporated in the anesthesia systems.\cite{19-21} The total amount of anesthetics released in the atmosphere can thus be reduced by 40-75%.\cite{16} Xenon, an inert gas naturally present in the atmosphere, is devoid of greenhouse effect, but the energy and cost required for its production will mitigate its clinical use.\cite{14}

More than the environmental pollution, it is the staff working inside the operating rooms that is more at risk of exposure to the deleterious effects of inhalational agents. Most common example is extreme somnolence with the use of halothane with high flows, which can lead to wavering alertness and increased susceptibility to accidents both inside and outside the operating rooms.

The main limitation of our survey was a low response rate. The anesthesiologists who responded seem to be motivated and show an inclination toward the global aspect of the speciality, willing to embrace newer trends and technologies. Unfortunately, the percentage of such people was not very high. Therefore, the results cannot be generalized to the entire fraternity.

To conclude, while the practising anesthesiologists who participated in the survey were not fully aware of the
greenhouse effect and its implications, their clinical practice inadvertently is such that it minimizes the environmental pollution due to anesthesia. Better resources should be made available to further improve the fraternity’s contribution to a clean and safe environment.

REFERENCES

1. Byrick R, Doyle DJ. Volatile anaesthetics and the atmosphere: An end to ‘scavenging’? Br J Anaesth 2001;86:595-6.
2. Logan M, Farmer JG. Anesthesia and the ozone layer. Br J Anaesth 1989;63:645-7.
3. Sherman SJ, Cullen BF. Nitrous oxide and the greenhouse effect. Anesthesiology 1988;68:816-7.
4. Ravishankara AR, Daniel JS, Portmann RW. Nitrous oxide (N\textsubscript{2}O): The dominant ozone-depleting substance emitted in the 21st century. Science 2009;326:123-5.
5. Sharma S, Bhattacharya S, Garg A. Greenhouse gas emissions from India: A perspective. Curr Sci 2006;90:326-33.
6. Molina MJ, Rowland FS. Stratospheric sink for chlorofluoromethanes: Chlorine atom catalysed destruction of ozone. Nature 1974;249:810-2.
7. Farman JC, Gardiner CJ, Shanklin DD. Large losses of total ozone in Antarctica reveal seasonal Cl\textsubscript{2}/NO\textsubscript{x} interaction. Nature 1985;315:207-10.
8. United Nations Environment Programme (UNEP). Report of the Eighth Meeting of the Parties to the Montreal Protocol on Substances That Deplete the Ozone Layer, Costa Rica, 1996.
9. O’Hare B, Fitzpatrick GJ. General anesthesia and the environment. Irish Med J 1994;87:149-50.
10. Brown AC, Canosa-Mas CE, Parr AD, Pierce JM, Wayne RP. Tropospheric lifetimes of halogenated anaesthetics. Nature 1989;341:635-7.
11. Langbein T, Sonntag H, Trapp D, Hoffmann A, Malms W, Roth EP, et al. Volatile anaesthetics and the atmosphere: Atmospheric lifetimes and atmospheric effects of halothane, enflurane, isoflurane, desflurane and sevoflurane. Br J Anaesth 1999;82:66-73.
12. Forster P, Ramaswamy V, Artaxo P, et al. Changes in atmospheric constituents and in radiative forcing. In: Solomon S, Qin D, Manning M, et al., editors. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2007.
13. Ramaswamy V, Boucher O, Haigh J, Hauglustaine D, Haywood J, Myhre T, et al. Radiative Forcing of Climate Change. New York: Cambridge University Press; 2001.
14. Shine KP. Climate effect of inhaled anaesthetics. Br J Anaesth 2010;105:731-3.
15. Sulbaek Anderson MP, Sander SP, Nielsen OJ, Wagner DS, Sanford TJ Jr, Wallington TJ. Inhalation anaesthetics and climate change. Br J Anaesth 2010;105:760-6.
16. Ishizawa Y. General anesthetic gases and the global environment. Anesth Analg 2011;112:213-6.
17. Ryan SM, Nielsen CJ. Global warming potential of inhaled anesthetics: Application to clinical use. Anesth Analg 2010;111:92-8.
18. Gardner RJ. Inhalation anaesthetics – exposure and control: A statistical comparison of personal exposures in operating theatres with and without anaesthetic gas scavenging. Ann Occup Hyg 1989;33:159-73.
19. Thomasson R, Luttrupp HH, Werner O. A reflection filter for isoflurane and other anaesthetic vapours. Eur J Anaesthesiol 1989;6:89-94.
20. Enlund M, Wiklund L, Lambert H. A new device to reduce the consumption of a halogenated anaesthetic agent. Anaesthesia 2001;56:429-32.
21. Tempia A, Olivei MC, Calza E, Lambert H, Scotti L, Orlando E, et al. The anesthetic conserving device compared with conventional circle system used under different flow conditions for inhaled anesthesia. Anesth Analg 2003;96:1056-61.

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