Environmental and occupational hazards of the anesthesia workplace

Earth Day 1990, held on April 22 throughout the world, taught us much about the problems of our global environment and at the same time challenged us to ask questions about factors in our anesthesia workplace which may adversely affect the environment. We learned that scientists now estimate 3-5% of the ozone layer, which protects us from exposure to ultraviolet rays, has been destroyed by chlorofluorocarbons (CFCs), increasing our risk of cataracts and skin cancer.1 (See Figure 1.) But what about the volatile anesthetic agents, hydrochlorofluorocarbons (HCFCs), which closely resemble the CFCs? Are these gases also contributing to the destruction of the ozone layer?

We were reminded that "greenhouse gases" such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and ground level ozone prevent escape of infrared radiation, trapping heat close to the earth's surface and contributing to global warming.2 Does the quantity of N₂O used in anesthetics around the globe make a significant contribution to this greenhouse effect?

Our attention was focused on beach wash-ups of medical waste resulting from ocean dumping, which became common practice as landfills closed. How does the volume of garbage generated from disposable products in operating rooms impact on the environment, and what kind of health risks are created because of infectious waste material? And what about occupational hazards associated with waste gases, radiation, lasers and chemicals in our operating rooms? Answers to these questions give us a better understanding of how our workplace affects our personal health and the health of our global environment.
Anesthetic gases and the ozone layer

The CFCs used as refrigerants, solvents and propellants are greatly responsible for the destruction of the ozone layer. They are very stable in the atmosphere and have a long lifetime of 40-150 years, which permits travel above the ozone layer where atomic chlorine is released as molecules are broken down by ultraviolet radiation or photolysis. Each free chlorine atom destroys up to 100,000 molecules of ozone as it descends to the lower atmosphere where it combines with hydroxyl radicals to form hydrochloric acid which is returned to the earth's surface in the form of rain.

All three volatile anesthetic agents vented into the outside air (halothane, enflurane and isoflurane) are HCFCs that are very unstable and have an atmospheric lifetime of only 3-5 years, which is too short to allow random diffusion transport into the stratosphere where damage to the ozone layer occurs. The anesthetic HCFCs are considered "ozone friendly" because they react with carbon hydrogen bonds when exposed to hydroxyl radicals in the atmosphere to ultimately produce hydrochloric acid (HCL), hydrobromic acid (HBr) and CO₂ which are returned to earth by rain, ensuring that only a small percentage of HCFCs ever reaches the stratosphere. It is estimated that only 1% of halothane ever reaches the ozone layer. This "ozone friendliness" from an industrial viewpoint means HCFCs, which are 95% less damaging to the ozone layer, may be considered as replacements for CFCs.

Annual global production of the two most commonly used CFCs estimated to be responsible for 70% of all ozone destruction is 630,000 tons in comparison with 6,400 tons of anesthetic HCFCs. Scientists estimate halothane's responsibility for ozone destruction to be only one-thousandth of 1%.

Widespread public concern regarding destruction of the ozone layer resulted in a ban on the use of (not production of) CFCs in the '70s. The Antarctic ozone hole brought a renewed commitment to protect the ozone layer, and a United Nations Environment Programme Convention was signed in 1985, followed by the Montreal Protocol in September 1987, which listed substances harmful to the ozone layer. The anesthetic HCFCs were not considered harmful enough to be included.

Greenhouse gas effect

The "greenhouse effect," which normally keeps our planet warm, has been altered by burning fossil fuels and deforestation. Fossil fuels increase emission of gases such as CO₂, and the absence of trees prevents the normal absorption of CO₂ from the atmosphere. These increased "greenhouse gases" form a blanket preventing the escape of heat from the surface of the earth, which then contributes to global warming and threatens habitability of the planet. Scientists estimate CO₂ is responsible for 50% of the greenhouse effect, CFCs are responsible for 15-20%, CH₃ is responsible for 18%, N₂O is responsible for 10% and ground level ozone is responsible for 3-5%.

The fact that N₂O contributes to the greenhouse effect leads us to ask what happens to the N₂O administered in most general anesthesics? As N₂O is vented to the outside air, it reacts with atomic oxygen to produce nitric oxide (NO), which does adversely affect the ozone layer and is also a greenhouse gas. The tropospheric concentration of N₂O is estimated to be increasing at a rate of approximately 0.25% per year, largely as a result of the microbial breakdown of agricultural nitrates. The total N₂O formed from agricultural products combined with the total N₂O used for anesthetic purposes is thought by some scientists to equal quantities great enough to contribute to the problem of global warming.

Medical waste

Public concern over beach wash-ups in the summer of 1987 prompted the United States Congress to pass the Medical Waste Tracking Act of 1988. Under direction of the U.S. Environmental Protection Agency (EPA), the Medical Waste Tracking Act requires pilot program hospitals in New York, New Jersey and Connecticut to set up waste tracking systems to separate, package and label medical waste; track it from generation to final disposal; and report the results. After one year of a two-year mandated program, the study concludes that the real hazards from medical waste are not to the environment or to the public but are occupational in nature. Most healthcare institutions in the United States are developing hazardous waste management departments in response to Occupational Safety and Health Administration (OSHA) standards, Joint Commission on Accreditation of Healthcare Organizations (JCAHO) regulations and state regulations.

Two important reports from studies by the U.S. Agency for Toxic Substance and Disease Registry and the Centers for Disease Control conclude that injuries from medical waste are rare, the chance of AIDS transmission is remote, and there is no epidemiologic evidence that hospital waste is more infectious than residential waste. Infectious waste must be clearly defined into such categories as:

1. Cultures and stock of microorganisms and biologicals.
2. Blood and blood products.
3. Pathological wastes including tissues, organs, body parts and body fluids.
4. Sharp objects such as needles, syringes and scalpels used in patient care.

Workers must be trained to segregate infectious wastes into “red bag” containers which are then treated by incineration or steam sterilization for a minimum of 90 minutes at 250 degrees F at 15 pounds pressure. Chemical decontamination and sanitary sewerage treatment can also be utilized to prevent threats to workers.

Alternatives to disposable products must be explored in order to reduce the overwhelming amount of waste generated by these products and their packaging. Recycling of glass, plastics, paper and aluminum must be considered. The use of styrofoam should be eliminated, since the styrofoam cup that held your morning coffee will remain on earth for 500 years.

**Occupational hazards of waste gases**

Air pollution from waste gases became a major issue in the anesthesia workplace in the early ‘70s. Research showed strong scientific evidence of the health hazard associated with chronic exposure to waste gases. Because of this possible health hazard, the National Institute for Occupational Safety and Health (NIOSH) issued a recommendation in 1977 that N2O be controlled to an eight-hour time weighted exposure of 25 parts per million (ppm), and halogenated agents are not to exceed .5 ppm when combined with N2O and below 2 ppm when used alone. These regulations led to the installation of scavenging systems to ventilate waste gases to outside air.

Studies in 1985 showed N2O inactivates vitamin B12, resulting in interference with DNA production. This study reinforced the concern of operating room personnel regarding the hazards of chronic exposure such as abnormalities of childbearing and diseases of the nervous system. Even with scavenging systems, there is continued anxiety among anesthesia providers as to what extent trace gas pollution can cause illness or injury. In one study, 21% of participants reported adverse health effects such as headache and fatigue which they attributed to the pollution.

Waste gases were found in high concentrations, even in operating rooms with scavenging systems and the turbulent airflow nonrecirculating systems required in most institutions today. Using spectrophotometric light absorption by airborne chemicals, the highest concentrations of gases were isolated between the gas machine and the adjacent wall and along the perimeter of the patient drapes. Levels around the patient’s mouth were often in excess of 200 ppm. High concentrations in breathing zones of anesthesia providers resulted in 2-4 times more exposure than other personnel. The study concluded that waste anesthetic levels are greatly affected by techniques and work practices.

The most common leak sites identified were hose connections to the machine, disposable breathing circuits, ventilators, pop-off valves and vaporizers. Other major sources of leaks included:

1. Endotracheal tube cuffs which are insufficiently inflated.
2. Uncuffed tubes in children.
3. Face masks which are poorly fitted in edentulous or bearded patients.
4. Gas flow turned to “on” position before placing mask on patient.
5. Vaporizers refilled in the “on” position.

Recommendations to decrease exposure include effective scavenging vacuum lines to maintain a minimum flow rate of 440 ppm and a ventilation system that complies with a minimum of 20 room changes per hour required by the U.S. Department of Health and Human Services (HHS).

N2O has been used in almost every general anesthetic over several decades, but if it were a new drug some experts doubt that it would receive U.S. Food and Drug Administration (FDA) approval. Although N2O permits the maintenance of normal PaCO2 and may increase both heart rate and systemic and pulmonary blood pressure, it can depress ventilation and circulation in much the same way as volatile agents. Toxic effects may affect the brain, lung, liver, kidney, blood and fetus adversely. Its ability to increase pressure in the middle ear or stimulate the sympathetic nervous system may contribute to the problem of nausea and vomiting. N2O is contraindicated in air embolism and pneumothorax, and diffusion hypoxia can occur at the end of a case when outpouring of N2O dilutes alveolar O2 and CO2, causing decreased oxygenation.

The bottom line is that the risk/benefit ratio for N2O may exceed that for other anesthetics. Perhaps anesthesia providers should make a conscious decision to use it only to facilitate induction and in short procedures. Although debate continues, prudent practice suggests that exposure be held to the lowest possible level. The scientific evidence of health hazards accompanying anesthetic exposure presents a strong argument for reducing N2O levels in operating rooms.

**Occupational hazards of radiation and lasers**

Anesthesia is frequently administered to patients receiving x-ray radiation, which has been shown to modify molecules within cells. It is often impossible for the anesthesia provider to leave the
room to prevent exposure. Therefore, we must maintain the greatest practical distance from the source of radiation and wear leaded shields in the form of aprons and collars for protection.

There are two types of radiation, ionizing and nonionizing. Ionizing radiation includes x-rays, fluoroscopies and radioactive implants and has been shown to cause congenital abnormalities and cancer. (See Table I for the Association of Operating Room Nurses [AORN] recommended practices for radiological safety in the practice setting.) Laser, an acronym for light amplification by stimulated emissions of radiation, is nonionizing radiation. Studies show that hazards do not include malignancy but are primarily related to the high degree of temperature and thermal action and the possible infection from viral DNA escaping in particulate matter into the air from the copious plume of smoke. Cautious, careful smoke evacuation is recommended, along with frequent filter changes and double masks.

Table II details the AORN recommended practices for laser safety in the practice setting.

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### Table I

**Recommended practices for radiological safety in the practice setting**

<table>
<thead>
<tr>
<th>Recommended Practice</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>The patient should be protected from unnecessary exposure to x-rays.</td>
</tr>
<tr>
<td>II</td>
<td>All personnel should be protected from unnecessary exposure to x-rays in the practice setting.</td>
</tr>
<tr>
<td>III</td>
<td>Radiation monitoring devices should be worn by personnel who are in frequent proximity to radiation.</td>
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<tr>
<td>IV</td>
<td>Leaded protective devices should be handled carefully and examined periodically to prevent damage that could diminish their effectiveness.</td>
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<tr>
<td>V</td>
<td>Personnel should be protected from exposure to patients who have received diagnostic or therapeutic radionuclides that may pose a radiation risk.</td>
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<tr>
<td>VI</td>
<td>Activities in the practice setting should be planned to minimize exposure to therapeutic radiation sources.</td>
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<tr>
<td>VII</td>
<td>Measures taken to protect the patient from direct and scatter radiation should be documented.</td>
</tr>
<tr>
<td>VIII</td>
<td>Policies and procedures on radiation safety in the operating room should be written, reviewed annually and readily available within the practice setting.</td>
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</table>


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### Table II

**Recommended practices for laser safety in the practice setting**

<table>
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<th>Recommended Practice</th>
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</tr>
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<tbody>
<tr>
<td>I</td>
<td>All health care workers should be alerted to laser use areas and associated admittance restrictions.</td>
</tr>
<tr>
<td>II</td>
<td>Eyes of patients and health care workers should be protected from laser beams.</td>
</tr>
<tr>
<td>III</td>
<td>Skin and other tissues of patients and health care workers should be protected from aberrant and reflected laser beams.</td>
</tr>
<tr>
<td>IV</td>
<td>Patients and health care workers should be protected from inhaling fumes associated with laser use.</td>
</tr>
<tr>
<td>V</td>
<td>Patients and health care workers should be protected from fire hazards associated with laser use.</td>
</tr>
<tr>
<td>VI</td>
<td>Patients and health care workers should be protected from electrical hazards associated with laser use.</td>
</tr>
<tr>
<td>VII</td>
<td>Policies and procedures for laser safety should be developed within the practice setting.</td>
</tr>
</tbody>
</table>

Chemical hazards

It is estimated that 60% of all healthcare workers are exposed regularly to numerous toxic chemicals such as phenols, acetone, ether and alcohol. Ethylene oxide used in gas sterilization is carcinogenic and a mutagen in animal studies. OSHA regulations allow 1 ppm maximum exposure in eight hours. Formaldehyde has been shown to be carcinogenic, mutagenic and hepatotoxic, and OSHA allows 5 ppm per eight-hour shift maximum exposure. All chemicals should be used with caution, especially if they are flammable.

Summary

Our present state of research and knowledge strongly suggests that the volatile agents, halothane, enflurane and isoflurane, present only a minimal threat to our environment. Nitrous oxide, however, has ozone-depleting potential as well as a greenhouse gas effect which may contribute much to the problem of global warming over the next few decades. Release of anesthetic gases into the atmosphere presents a small problem in contrast to other sources of ozone-depleting chemicals and greenhouse gases, but anesthesia providers have a responsibility to minimize unnecessary atmospheric pollution by reevaluating the use of N2O, using low flows of gases and exploring the use of activated charcoal absorption in the scavenging systems to remove volatile agents.

Infectious waste, radiation, lasers, chemicals and waste gases pose possible occupational health hazards in the operating room. Each of us should play a critical role in monitoring harmful substances and should actively practice techniques which would lessen the hazards. We should be cognizant of the fact that sources not yet introduced into our environment may have adverse effects on our health and that vigilance and education are key factors in maintaining a safe work environment.

REFERENCES


AUTHOR

Terrie E. Kole, CRNA, BA, received her anesthesia education from Norfolk General Hospital, School of Anesthesia, Norfolk, Virginia, and her Bachelor of Arts in Health Care Administration from Ottawa University, Kansas City, Kansas. Ms. Kole has written for Encyclopedia Britannica and Anesthetist Update Series, and she has also authored several textbook chapters and numerous journal articles. She has lectured extensively in areas of outpatient anesthesia, office practice anesthesia and anesthesia for plastic surgery.

Ms. Kole is past president of the Virginia Association of Nurse Anesthetists and has served on AANA committees. She currently has a private practice in plastic surgery, as well as a position as staff anesthetist at Riverside Regional Medical Center, Newport News, Virginia, where she is chairman of a committee to study occupational and environmental hazards in the operating room. Ms. Kole was recently commissioned as a captain in the U.S. Army Reserves.