13 Waste Anesthetic Gases (WAGs): Minimizing Health Risks and Increasing Awareness

John E. Moenning Jr., Dina A. Krenzischek, and James D. McGlothlin

13.1 Introduction

The scavenging of waste anesthetic gases (WAGs) is recommended by every professional organization and government agency involved with anesthesia to reduce occupational exposure to healthcare personnel [1]. WAGs in healthcare environments have been associated with adverse health outcomes in unscavenged situations [2–13]. Methods to decrease occupational exposure by scavenging WAGs and minimizing potential health problems is important in both the operating room (OR) and in the postanesthetic care unit (PACU) [14, 15]. By extension this also means it is important to discuss WAG in relation to any imaging environment where anesthesia is used as well as the imaging procedure recovery area.

13.2 Standards and Guidelines for WAG

Assuring that employers provide safe working conditions for employees was the purpose of the Occupational Safety and Health Act of 1970, Public Law 91-596 [16]. This act created the Occupational Safety and Health Administration (OSHA) under the US Department of Labor, and the National Institute for Occupational Safety and Health (NIOSH) under the Department of Health and Human Services. OSHA and NIOSH are federal agencies concerned with possible health hazards to employees associated with exposure to WAGs. Other recommending bodies that publish occupational exposure information are the American Conference of Government Industrial Hygienists (ACGIH), the American Society of Anesthesiology (ASA), the American Dental Association (ADA), and the Joint Commission (TJC), also known as the Joint Commission on Accreditation of Healthcare Organizations (JCAHO).

In 1977, NIOSH promoted research on the effects of occupational exposure to WAGs, the means for preventing occupational injuries, and recommended occupational safety standards [17]. It made recommendations to four areas of occupational health: (1) scavenging and exposure to trace WAG concentrations; (2) work practices to minimize WAG concentrations; (3) medical surveillance for possible occupational exposure

J. E. Moenning Jr, DDS, MSD
Indiana Oral & Maxillofacial Surgery Associates, Fishers, IN, USA

D. A. Krenzischek, PhD, RN, CPAN, FAAN (✉)
Patient Care Service, Mercy Medical Center, Baltimore, MD, USA

J. D. McGlothlin, PhD, MPH, CPE, FAIHA
Emeritus Purdue University, West Lafayette, IN, USA

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in the healthcare environment, and (4) monitoring WAGs. NIOSH recommended that workers should not be exposed to halogenated agents at concentrations of >2 parts per million (ppm) when used alone or >0.5 ppm when used in combination with nitrous oxide over a sampling period not to exceed 1 h. NIOSH also recommended that occupational exposure to nitrous oxide, when used as the sole anesthetic agent, should not exceed a time-weighted average of 25 ppm during the time of anesthetic administration. In addition, this federal agency recommended that all anesthetic gas machines, non-rebreathing systems, and t-tube devices have an effective scavenging device that collects all WAGs. Within these recommendations, the agency provided a thorough discussion of other work-practice techniques, such as turning on the scavenging system before administering anesthetic gases to the patient to minimize WAG exposure to medical staff.

In 1989, the ACGIH assigned a threshold-level limit value time-weighted average for nitrous oxide of 50 ppm for an 8-h work day [18]. ASA, in its Guidelines for Non-Operating Room Anesthesia Locations, approved by its House of Delegates in 1994, stated that in any location that inhalation agents are administered, there should be adequate and reliable systems for scavenging WAGs [1]. The ADA recommends the scavenging of all WAGs for all procedures involving anesthetic gases in the dental office [15]. Finally, in 1997, JCAHO recommended that educational programs and orientation should be established for all personnel who have contact with hazardous materials and waste.

Other countries around the world have also established standard guidelines to occupational exposure for nitrous oxide. These can range anywhere from 25 ppm (the Netherlands) to 100 ppm (Italy, Sweden, Norway, Denmark, and Great Britain) [19, 20].While some of these government agencies and healthcare associations have different occupational exposure standards in regard to ppm, all unanimously agree that scavenging WAGs should be utilized.

OSHA's responsibilities are to adopt and mandate job safety and health standards, establish the rights and responsibilities of employers and employees for safe occupational conditions, establish recordkeeping and reporting procedures of injuries, and evaluate work-related safety practices (Table 13.1). OSHA is also responsible for carrying out NIOSH recommendations [21]. Currently, OSHA recognizes NIOSH-recommended exposure limits (RELs) to WAG exposure, but to date, it has not set its own standards for WAGs. However, OSHA can cite under the General Duty Clause 5a(1), which states, "each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees" [22].

To minimize and create an environment as safe as possible for healthcare workers, NIOSH recommends a well-designed scavenging system as part of an anesthetic delivery system for collecting WAGs. These recommendations apply to any place where anesthetic agents are delivered, as well as to the PACU. Patients may out-gas (i.e., exhale) anesthetic agents following their surgical procedures; NIOSH recognizes that close proximity to patients can result in exposure to quantifiable concentrations of WAGs. It also indicates that while random room samples may indicate relatively low levels of WAGs, the breathing zone of the nurse in close proximity to the recovering patient may expose that nurse

Table 13.1 OSHA guidelines to manage WAG risks in the OR and PACU

Facility design and engineering
WAG scavenging systems in the OR
Room air changes (OR: 15 with 3 fresh/h; PACU: 6 with 2 fresh/h)
Isolated fresh air intakes
Administrative
Work practices, training, hazard communication
Professional organization guidelines (e.g., ASA, ADA)
Maintenance and proper use of equipment
Installation of proper equipment, calibration, and maintenance
Periodic leak checks

Source: Occupational Safety and Health Administration, U.S. Department of Labor. (Revised 2000, May). Anesthetic Gases: Guidelines for Workplace Exposures. Retrieved from http://www.osha.gov/dts/osta/anesthetic-gases/index.html to levels of anesthetic gases that are above the NIOSH RELs. In 2007, NIOSH Publication No. 2007-151 reemphasized these recommendations in regard to WAGs [23]. This publication intended to increase awareness of the adverse health effects of these gases, describe how workers are exposed to WAGs, and recommend work practices to reduce these exposures and identify methods to minimize leakage of WAGs into the work environment. Steege et al., in their 2014 NIOSH-sponsored survey, found that 56% of workers dealing with anesthetic gases were unaware whether their employer had standard procedures for handling/minimizing exposure to these gases [24].

13.3 WAG Risks: Toxicology and Mechanisms

Lassen et al., in a 1956 Lancet article, found that severe bone marrow depression could occur after prolonged nitrous oxide anesthesia in some patients who were being treated for tetanus [25]. Later in 1967, the first indication that anesthetic gases could be a problem for humans was reported by Russian scientist Vaisman [26], who reported that female anesthesiologists had had problems with fatigue, nausea, and headaches, and that 18 of 31 pregnancies ended in spontaneous abortion. In 1968, additional articles with regard to nitrous oxide and its effects on bone marrow were reported. Banks et al. and Amess et al. reported that nitrous oxide can inactivate vitamin B12 and thus cause biochemical derangements similar to those seen in pernicious anemia [27, 28]. In 1974, Bruce et al. published their studies dealing with nitrous oxide and audiovisual impairment [29]. In 1977, NIOSH reported that levels of 50 ppm for nitrous oxide were the lowest level at which human effects had been reported [17]. NIOSH quoted audiovisual impairments that Bruce et al. illustrated.

In 1980, Cohen et al. published an article reporting on health problems experienced by dentists and chairside assistants who had been exposed to nitrous oxide in their jobs [6]. They considered dentists as having light exposure if they used nitrous 1–8 h a week, or heavy exposure if used >8 h a week. They found the following information: nitrous oxide use doubled the likelihood for congenital abnormalities or spontaneous abortions; nitrous oxide was shown to have an increased effect on neurologic problems, as well as liver and renal problems for male dentists and assistants; and nitrous oxide use doubled the likelihood for cervical CA in the female study group.

In 1992, Rowland et al. reported that fertility problems occurred in women exposed to high levels of unscavenged nitrous oxide [12]. They also found a 2.5-fold increase in spontaneous abortions experienced by women who worked in dental operatories that did not scavenge nitrous oxide and found no increase in infertility or spontaneous abortion in women who worked in dental operatories that scavenged waste nitrous oxide.

In a government technical report, McGlothlin et al. (1994) reported similar findings from the literature, where the effects of acute and chronic occupational exposure had been shown to cause bone marrow depression (primary granulocytopenia), paraesthesia, difficulty concentrating, equilibrium disturbances, and impaired visual effects [30].

As a result of numerous epidemiological evaluations, the ASA commissioned a group of epidemiologists and biostatisticians to evaluate the significance of these studies with regard to possible health hazards resulting from exposure to WAGs. Buring et al. reviewed 17 published studies, and after evaluating these studies for the best statistical controls they concluded that there was a 30% increased risk of spontaneous abortion for women working in operating rooms and a similar, but less consistent increase in congenital abnormities among offspring of exposed physicians [31]. They also concluded that all of the studies reviewed had weaknesses in their response rates and other confounding variables, making it difficult to draw specific conclusions.

A study by Krajewski looked at alterations in the vitamin B12 metabolic status of 95 operating room nurses with a history of exposure to nitrous oxide and compared them to 90 nurses who were not exposed to nitrous oxide [32].They found significantly lower vitamin B12 status in personnel exposed to nitrous oxide with higher total homocysteine levels. The changes in vitamin B12 status were found to be primarily in subjects who were exposed to nitrous oxide in concentrations substantially exceeding occupational exposure limits.

In 2008, Sanders et al. published a thorough review of the biological effects of nitrous oxide, including how nitrous oxide affects methionine synthase function [33]. They discussed as a result of the interaction of vitamin B12 with nitrous oxide, methionine synthase is inactivated, resulting in alterations to one carbon and a methyl group transferred, which is important for DNA, purine, and thymidylate synthesis. These alterations potentially may result in the increased risk for reproductive consequences, megaloblastic bone marrow depression, neurologic symptoms, and increased levels of homocysteine, which can cause cardiovascular changes.

While the anesthetic use of nitrous oxide with halogenated agents may be decreasing, the use of halogenated agents has not gone down. The agents, sevoflurane, isoflurane, and desflurane, make up the vast majority of inhalation anesthetic gases. Fodale reviewed 54 articles on the health effects of nitrous oxide and halogenated gases and found that these agents were associated with general health and genotoxic risks and stressed the need for further studies [34]. Recently, studies on humans and rodents have shown that low-dose anesthetic gases can cause changes in liver blood chemistry, DNA damage, and antioxidant status [35–38].These reviews create significant debate about the long-term effects of anesthetic agents. These possible health changes become even more concerning in the developing brains of children and the elderly, and these neurocognitive issues are being investigated by the Federal Food and Drug Administration (FDA) in the USA [39]. As a result, all organizations have concluded that good scavenger systems are needed to decrease these possible health consequences from exposure to WAGs with halogenated agents and/or nitrous oxide gas.

13.4 WAGs in the PACU

In 1996, the American Society of Perianesthesia Nurses (ASPAN) issued a position statement in regard to air safety in the postanesthesia environment [40]. It stated that necessary, appropriate, and protective engineering controls, technologies, work practices, and personal protective equipment be utilized in the perianesthesia environment. ASPAN recommended that occupational exposure to WAGs, and blood-borne and respiratory pathogens, be controlled by adherence to regulations and guidelines set forth by nationally recognized agencies, such as NIOSH, the Centers for Disease Control and Prevention (CDC), and OSHA's hierarchy of controls based on principles of good industrial hygiene.

In 1997, an article by Badgwell discussed air safety source control technology for the PACU [41]. In addition, Brodsky concluded his review of the literature by stating, "Why risk potential health and reproductive problems while waiting for definitive proof, when this is not likely to be forthcoming. Even without direct proof of cause, we should reduce levels of WAG to their lowest possible concentration by careful use of efficient control measures" [42]. Badgwell also stated that as a result of the body of research and careful analysis, the inclusion of source-control scavenging has become the de facto standard for anesthetic machines in all operating rooms in the USA since 1980 [41].Badgwell also reviewed literature related to exposure of PACU personnel to WAGs and concluded that WAG levels in the breathing zone of personnel in the PACU appeared to exceed NIOSH RELs. Over the last 10 years, articles have begun to appear with regard to WAG levels in the PACU. Prospective studies have looked at exposure levels in the PACU. Sessler et al. recently summarized several papers on healthcare personnel exposed to WAGs and possible health concerns from this exposure [43]. He reported that the majority of these studies concluded that there is a correlation between reproductive toxicity and exposure to WAGs. The majority of these health concerns involve spontaneous abortions and infertility; neurobehavioral effects; megaloblastic anemia; neuropathies; psychophysiological effects of impaired cognitive, perceptual, and/or motor function; and more recently vitamin B12 deficiencies and homocysteine elevations.

Sessler and Badgwell [43] found that postoperative nurses were frequently exposed to exhaled anesthetic gas concentrations exceeding NIOSH-recommended exposure levels. Interestingly, they found that volatile anesthetic curves did not demonstrate the expected exponential decrease over time. They found that one-fourth of the nurses demonstrated time-weighted average (TWA) that exceeded the 25 ppm NIOSH recommendations, even though they had been caring for patients who had received nitrous oxide-free anesthesia. Sessler points out that this could have been due to limitations in ventilation air exchanges in the PACU design. The data suggested that PACU nurses were exposed to exhaled anesthetic gases exceeding the NIOSH RELs.

Krenzischek found that concentrations of nitrous oxide were close to 300 ppm in a patient's breathing zone [44]. This pilot study identified the potential for staff exposure to WAGs in the PACU setting. A simulated PACU environment was constructed to obtain an understanding of how the concentration of nitrous oxide varies with distance from the patient. Austin found that the concentration of nitrous oxide decreases with distance from the patient and the patient's respiration increases the level of nitrous oxide based on the location of the nurse. Also, the respiration of the nurses pulls the nitrous oxide plume toward them, increasing their exposure to the gas [45]. Austin questioned the inadequacy of attempting to measure levels of gas exposure at random points in a room. There are other articles that have looked at breath analysis to determine whether PACU personnel or operating room personnel are inhaling the gases and then exhaling them at a measurable limit. Cope et al. and Summer et al. have found that exhaled anesthetic agents are present in the breath of personnel [46, 47]. In 2015, Cheung et al. found that WAG concentrations are higher in the patients' breathing zone when patients' airway devices are removed in the PACU vs. in the OR [48].

As stated earlier, it can be surmised that PACU personnel may be exposed to WAGs that are above NIOSH REL standards; this could have health consequences from exposure to WAGs. In addition, the potential for neurocognitive problems can result from chronic exposure. When nursing personnel are exposed to a large number of PACU patients throughout an 8-h day, the potential for cognitive problems may increase. This is important, considering that the Institute of Medicine (IOM) states that as many as 44,000 to 98,000 people die in US hospitals every year as a result of medical errors [49]. Furthermore, nonfatal adverse events related to medication errors can increase hospital costs by as much as $2 billion a year. IOM also states that higher error rates may be more common in emergency departments, operating rooms, or intensive care units (ICUs). Helmreich, in analyzing errors in aviation, found that multiple physiological and psychological factors impact attention spans and make medical errors more likely [50]. Some of the causes include increased workload, fatigue, cognitive overload, ineffective interpersonal communication, and faulty information processing. If cognitive problems are known to increase secondary to exposure to WAGs above NIOSH limits, it seems reasonable to conclude that minimizing exposure to WAGs would help prevent possible adverse health consequences to personnel, as well as decrease the potential for human error during the times patients are in the PACU.

13.5 Exposure Assessment Methods for Detecting WAGs

Evaluation of WAGs, particularly nitrous oxide, is typically done through three traditional methods. The first utilizes nitrous oxide dosimetry badges. These sampling monitors are very similar to radiology monitors, where the nitrous oxide gas is absorbed by a zeolite molecular sieve with a pore size of 5 angstroms. These sampling badges are opened at the beginning of a sampling period. Upon completion of the sampling phase, the badge is double-sealed in a bag and then sent to a lab for analysis.

A second method utilizes a small handheld infrared spectrophotometer. An example of one used in PACUs is the Medigas PM 3010 developed by the Bacharach Company in Pittsburgh, PA, USA. This handheld device pulls in the nitrous oxide to be analyzed by a small port and reads nitrous oxide concentrations by infrared analysis spectrophotometry. However, the device that has been used the longest for WAG monitoring has been the Miran 1B SapphIRE Ambient Air Analyzer (Thermo Fisher, Waltham, MA, USA). NIOSH RELs were all established by using the Miran infrared spectrophotometer. Recently, the use of Fourier transform infrared spectroscopy (FTIR) (Gasmet Technologies Oy, Finland) has become the standard for measuring gases. FTIR works by being able to measure the entire IR spectrum and thus measure multiple gases at the same time. While all of these devices measure WAGs as a part per million (ppm), none of these measuring devices can visualize gases.

By utilizing infrared thermography, a new way to visualize WAGs, especially nitrous oxide, has been established. An infrared camera (Merlin Mid-INSB Midwave FLIR infrared camera, FLIR Systems Inc., Boston, MA, USA) uses the infrared light through a special lens to capture the nitrous oxide molecule absorbing the infrared image in a spectrum of 45 to 50 nanometers. Using this technology has made it possible to visualize nitrous oxide, and most recently halogenated agents, and thus develop ways to minimize occupational exposure to personnel not previously possible. Specifically, this allows researchers to "see" where the WAGs may be escaping into the environment (Fig. 13.1).

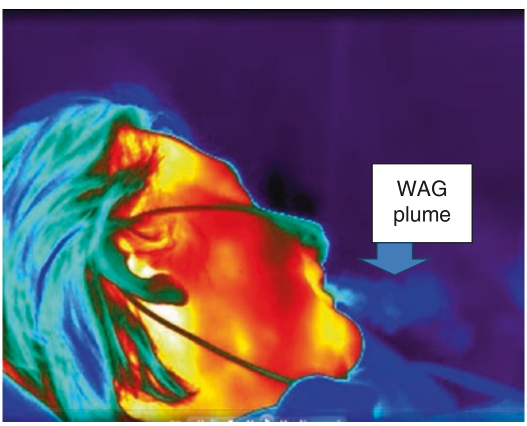

Fig. 13.1 New patient admitted to PACU following general anesthesia. The Infrared allows the visualization of the WAG as seen by the WAG plume from the mouth (Permission to re-print Dr. John Moenning Source)

This technology was utilized in a study that appeared in the February 2009 issue of the Journal of the American Dental Association (JADA) [51]. Two nitrous oxide scavenging systems were evaluated to determine their ability to control waste gas emissions. As a result of this study, it was discovered that nitrous oxide is present in the postoperative respirations of individuals long after discontinuation of the gas. The use of this technology was then taken to the PACU as a proof-of-concept to determine if WAG occurs in the breathing zone of recovering patients and exposes nurses to these exhaled WAGs.

To visualize possible WAGs in the PACU, identical instrumentation used in the JADA February 2009 issue was utilized. Preliminary data were collected using three types of instrumentation. These were infrared thermography by means of an infrared camera (Merlin Mid-INSB Midwave infrared camera, National Instruments Corporation, Austin, TX, USA), digital videography by means of a camcorder (Handicam, DCR-SR100, Sony, Tokyo, Japan), and real-time nitrous oxide and sevoflurane air concentration levels parts per million (ppm) by means of an infrared spectrophotometer (Miran 1B SapphIRE Ambient Air Analyzer, Thermo Fisher Scientific, Waltham, MA, USA) [52]. By using all three methods to measure WAGs, McGlothlin et al. proved that sevoflurane and nitrous are present in the PACU, are present in the patient's and nurse's breathing zones, are above the NIOSH RELs for extended periods of time, and can be controlled (Fig. 13.2).

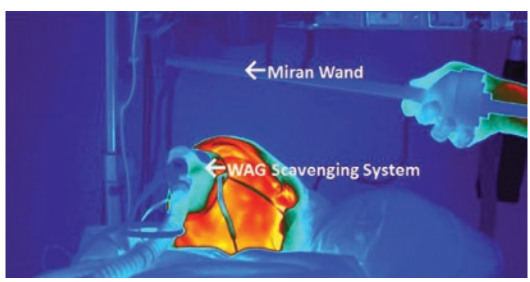

Fig. 13.2 WAG Scavenging System in place capturing the WAG's following general anesthesia (Permission to re-print Dr. John Moenning Source)

Hillar et al. also evaluated WAGs in the PACU and showed that the rate of washout of sevoflurane was dependent solely on the duration of the anesthetic exposure. They found that when their patients were extubated at 0.2% (2000 ppm) and assuming a constant cardiac output, even after 25 min (92% elimination), the concentrations would still be 184 ppm. To get to the current NIOSH RELs of 2 ppm would require a 98.998% reduction of the inhaled anesthetic gas and could take more than an hour [53]. In 2018, Tallent et al. also documented PACU WAGs in 120 patients after tracheal extubation in the patient breathing zone and nurse work zone. More importantly, they were able to document the reduction of elevated WAGs (exhaled Sevoflurane and Desflurane) in the PACU to concentrations below the NIOSH RELs in greater than 85% of extubated patients within 20 s of applying the ISO-Gard® scavenger mask [54].

Utilizing techniques to measure and visualize WAGs in the PACU has proven the existence of occupational exposure (Fig. 13.3) [52–54]. A review of the literature in regard to possible health concerns from postanesthetic gases and the conclusions from governing bodies and professional organizations indicate a general agreement that control of WAGs should be considered. Utilizing engineering controls, best-work practices, and personal protective equipment (such as a mask) should be used in the PACU environment. Developing methods and practices to minimize these WAGs is important. In fact, OSHA has stated, "the preferred and most effective means of protecting workers is to prevent hazards entering their breathing zone in the first place" [55].

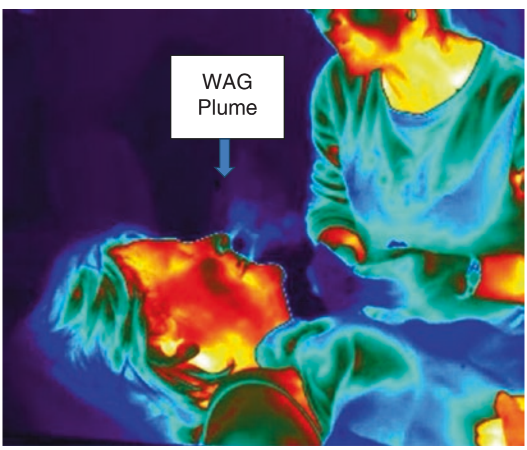

Fig. 13.3 Nursing personal in the breathing zone being exposed to the WAG (WAG plume) following general anesthesia (Permission to re-print Dr., John Moenning Source)

The American Society of PeriAnesthesia Nurses (ASPAN), at its National Meeting in 2016, identified the following issues pertinent to perianesthesia occupational hazard exposure prevention:

1. Exposure to waste anesthetic gases above NIOSH RELs exhaled by patients in the breathing zone of nurses providing care at the bedside and cross contamination to other PACU patients, including immune suppressed patients
2. Lack of sufficient monitoring within the breathing zone of PACU patients following general anesthesia
3. Lack of engineering control interventions to reduce the level of waste anesthetic gas exposure to healthcare workers (HCWs) and other patients
4. High risk of exposure for HCWs and patients to respiratory pathogens in the perianesthesia environment; open architectural designs including lack of air exchanges of perianesthesia care areas increase the risk of transmission of respiratory pathogens among patients and between patients and HCWs
5. Increased risk of exposure to droplet and airborne infectious diseases (e.g., M. tuberculosis [TB] and rubella virus [measles], and viral illnesses, such as norovirus, Ebola virus, and Zika virus) [56, 57]

As a result of all of the research, new techniques in monitoring and the visualization of WAGs ASPAN updated its position statement in 2016 [40] (Table 13.2).

Table 13.2 ASPAN's position states that "necessary, appropriate, and evidence-based protective engineering controls, technologies, work practices, and personal protective equipment be utilized in the perianesthesia environment" [40]. Key points of ASPAN's recommendations are to

- Promote a safe environment for nurses and patients
- Adhere to national regulations and guidelines to establish a hierarchy of controls based on principles of good industrial hygiene including waste anesthetic gases
- Protect healthcare workers and patients based on national regulations and evidence-based guidelines
- Support the development of healthcare policies, research collaborative projects that improves quality and safe environment including air quality and reduction of occupational exposure hazards

Source: 2019–2020 ASPAN Perianesthesia Nursing Standards, Practice Recommendations and Interpretive Statements: A Position Statement on Air Quality and Occupational Hazard Exposure Prevention (Permission to print by ASPAN)

13.6 Use of Scavenging Systems to Reduce and Prevent WAGs and Airborne Pathogens in the PACU

As discussed above, engineering controls, including scavenging systems in the PACU, are one of the most effective means to reduce and prevent exposure to WAGs. However, there are mounting concerns that nurses and related healthcare personnel in the PACU are also exposed to harmful airborne pathogens from patients' expired breath and nurses breathing this contaminated air during the patient's recovery. In fact, when a patient indicates that he or she has had a respiratory illness that could be harmful to PACU nurses, these patients are typically protected from exposing other patients by isolating them in a corner of the PACU. In addition, the nurses will wear additional respiratory protection (face shields, along with N-95 respirators). In some instances, the additional cost for these precautions are added to the patient's bill and/or is passed on to their provider. Because of this, many patients may not be forthcoming about their current or previous illnesses or may not even know that their airborne infectious diseases could harm the health of nurses in the PACU.

To address this issue, researchers at Purdue University have conducted preliminary research on the utility of market-available scavenging systems (e.g., ISO-Gard® [58]) to not only remove WAGs in the PACU, but also harmful airborne pathogens. As a proof of concept, the initial research was conducted in a Purdue University laboratory using a market-available scavenging system using state-of-the-art bioluminescence techniques [59]. The initial study showed a significant reduction in pathogens compared to not using the market-available scavenging system [60]. A follow-up study was conducted to better understand how well this market-available scavenging system worked to capture the bacteria, and where it deposited most of the bacteria in the scavenging system. Results showed that the bacteria were mostly concentrated in the patient's scavenging mask, then all along the exhaust tubing. Because of the success of both research studies (now pending publication) it was reasoned that this scavenging system could also benefit nurses in the PACU from airborne pathogens.

13.7 Translation of Evidence to Practice

There is increased attention to patient and workplace safety in healthcare facilities, which is driven by regulatory agencies, advocacy groups, litigators, and most importantly the patients or healthcare staff themselves. The most common challenge is not only the translation of evidence, but also the time it takes to drive change to practice despite published guidelines, policies, and evidence recommendations. Behavior change among organizations and/or individuals (providers, patients) is inherent in the translation process, engagement of stakeholder organizations, healthcare delivery systems, and individuals. This is important to achieving effective translation and sustained improvements [61].

13.8 Conclusion

Most PACU/recovery room (RR) nurses may not be aware of the WAG risks in their workplace environment. Understanding the evidence and putting it into practice is a start, especially toward increasing awareness. However, evidence and awareness are only meaningful when translated into practice. The assessment of potential risk in the clinical area and collaboration with appropriate resources (clinical chain of command and clinical engineering) are necessary steps in the implementation process. The clinical engineering department is responsible for monitoring potential WAGs in the OR/theater. In the PACU/RR, WAG assessment within the breathing zone of the patient can be monitored by clinical engineering health and safety professionals using appropriate monitoring devices. Monitoring of WAGs in the PACU has to be done on a routine basis whenever patients with anesthetic gas are admitted into the unit. Controlling the source of WAGs (typically from patients' exhalation in the PACU) protects not only the nurses but also other health-compromised patients. As a perianesthesia nurse in the PACU/RR or radiology post-recovery phase, the nurse's role is to provide safe and quality care to patients and be an advocate for a safe workplace environment. Protecting nurses and other healthcare staff from any risk of exposure, be it WAGs, airborne pathogens, infection, or any adverse outcome, is the responsibility of the entire healthcare team. So, extending the assessment, monitoring, and implementation of engineering control also means it is important to discuss WAG in relation to any imaging/interventional radiology environment where anesthesia is used as well as the imaging/interventional procedure recovery area.

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