# 88 Occupational Safety, Infection Control, and Substance Abuse

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**KEY POINTS**

- Exposure to waste anesthetic gas in clinical practice is unavoidable. In the United States, the limits of exposure to waste gases are set by the National Institute for Occupational Safety and Health (NIOSH), which recommends a time-weighted average of 25 ppm for nitrous oxide and a ceiling of 2 ppm for volatile anesthetics.
- Although researchers disagree whether exposure to anesthetic gases at concentrations less than NIOSH limits affects health or performance, these limits are often exceeded. If it can be smelled, the exposure is many times greater than the safe limit.
- Occupational exposure to radiation comes primarily from x-rays scattered by the patient and surrounding equipment. A distance of 3 feet from the patient is recommended to minimize physiologic damage from occupational exposure, and a distance of 6 feet from the patient provides the same protection as 2.5 mm of lead.
- Surgical smoke is increasingly recognized as a source of potentially infectious and carcinogenic material; evacuation devices should be used where the smoke plume is created.
- Diseases can be transmitted via direct contact, droplets, or airborne particles. Some diseases are infectious only if there is direct exposure to blood or body fluid from the host. Appropriate personal protective equipment based on the suspected type of infection should always be used to prevent occupational disease transmission.
- To attenuate occupational exposure to pathogens, standard precautions at a minimum should be used at all times. The appropriate barrier precautions for intubation include eye protection, a surgical mask, and gloves.
- To prevent exposure to bloodborne pathogens, sharps safety, including the use of safety retractable needles and needleless systems, should be used.
- Occupational exposure to human immunodeficiency virus (HIV) and hepatitis B and C viruses (HBV and HCV) is most often the result of a percutaneous injury. The risk of disease transmission is generally very low but is greatest from hollow-bore needles, needles contaminated with visible blood, and exposure to a source patient with high viral titer.
- Postexposure prophylaxis (PEP) is recommended after occupational exposure to HIV or HBV. The recommended guidelines for PEP are available on the Centers for Disease Control and Prevention website. The Clinical Consultation Center PEPline service is a free expert resource for guidance on PEP (1-888-448-4911).
- The preference for and access to potent opioids contribute to the prevalence of substance use disorder among anesthesiologists. The rate of drug-related deaths is more than twice as high in anesthesiologists as internists.
- Although many recovered anesthesiologists return to the practice of anesthesia, there is a significant relapse rate. The chance of relapse is highest in physicians who become addicted to potent narcotics early in their career. Successful recovery requires a lifelong commitment to treatment. In some cases, a change in specialty is the only solution.
- Sleep deprivation has an adverse effect on physician mood, cognitive function, reaction time, and vigilance. Although sleep deprivation and fatigue adversely affect clinical performance, the full impact on patient outcome has been difficult to determine.

The practice of anesthesiology exposes its practitioners to a variety of risks unique among medical specialties. Some of these risks are tangible or physical, such as waste anesthetic gases and communicable disease, whereas others are more insidious, such as stress, fatigue, and the risks of substance abuse disorder. Each of these risks can be mitigated but probably not eliminated.

In the case of physical exposures such as waste anesthetic gases, radiation, and bloodborne pathogens, efficient gas scavenger systems, the use of protective lead,

needle-shielded intravenous (IV) lines, standard precautions (SP), and postexposure prophylaxis (PEP) protocols are currently commonplace in contemporary anesthesia practice. The less tangible risks are harder to reduce. Work hour restrictions may limit fatigue among housestaff; however, doing so may not improve patient outcomes, particularly when such controls do not apply to practicing physicians. Substance abuse disorders remain a problem with a multifactorial etiology and few clear solutions. This chapter examines the risks associated with each of these environmental and situational hazards, and reviews the measures one can take to avoid them.

## Physical Exposures

### INHALATIONAL ANESTHETICS

Volatile inhaled anesthetics are an indispensable part of anesthesia practice; however, these agents also have the potential to cause harm to patients and the physicians caring for them. Given what is suspected about their impact on patient health, vis-à-vis neurodevelopment of the very young, the spectrum of postoperative cognitive dysfunction in adults, and immunosuppressant effects on patients of all ages,[1] it is natural to wonder whether these compounds are harmful to health care workers exposed to them on a daily basis.

Definitive answers remain elusive; it is difficult to randomize exposure, and previous work suggesting a link between exposure to waste anesthetic gas and infertility and other health effects suffered serious methodologic flaws. Still, the topic of the impact of exposure on cognitive performance and health continues to generate more questions than answers.

Waste nitrous oxide ($N_2O$) and halogenated anesthetics in the absence of scavenging may approach concentrations as high as 3000 and 50 ppm, respectively.[2] This is relative to guidelines for safe practice, which historically have proposed limits of exposure well below (e.g., 25 ppm $N_2O$ and 2 ppm of any halogenated agent).[3] Although the concentration of waste gases can be well controlled with proper scavenging, in practice the levels recommended by the National Institute for Occupational Safety and Health (NIOSH) are often exceeded during the routine delivery of anesthesia.[4,5] Although exposure to anesthetic gases is more common in pediatric anesthesia where mask inductions and uncuffed endotracheal tubes are more commonly used, the introduction of the laryngeal mask airway to anesthesia practice may increase operating room exposure to waste gases in adult cases as well. One study of inhaled induction of anesthesia and maintenance with sevoflurane and $N_2O$ in adults resulted in violations of NIOSH standards 50% of the time.[6]

#### Provider Health Effects

One of the first examinations of the impact of exposure to subanesthetic concentrations of inhalational anesthetics on cognitive performance was conducted by Bruce and Bach in the 1970s. They noted that healthy volunteers in the laboratory suffered a decrease in psychomotor performance when exposed to concentrations of $N_2O$ as low as 50 ppm, alone or in combination with 1 ppm of halothane. The same study showed that 25 ppm of $N_2O$ combined with 0.5 ppm of halothane had no effect.[3,7] Subsequently, three other groups of researchers studying volunteers in laboratories have been unable to confirm the earlier findings. The lack of agreement between investigators has led some to conclude "that there is no convincing evidence that anesthetics in concentrations equal to those found in unscavenged operating theatres have any effect on the psychomotor performance of healthy subjects in the laboratory."[8] A study conducted on volunteers in an operating room during normal clinical activities in which trace concentrations of $N_2O$ and halothane ranged from 0 to 2300 and 0 to 37 ppm, respectively, also failed to detect impairment in psychomotor performance.[9] In contrast, a series of studies in healthy volunteers showed that subanesthetic concentrations of $N_2O$, isoflurane, and sevoflurane were associated with reductions in psychomotor performance, with some studies suggesting a dose-dependent effect for $N_2O$ dose as low as 10% and a sevoflurane dose as low as 0.4%.[10-12] By way of comparison, 10% $N_2O$ is equivalent to 100,000 ppm, significantly higher than the recommended safe level of exposure and the level of exposure in the Bruce and Bach studies. Whether the methods in these studies closely mimic patterns of occupational exposure in clinical practice is debatable, but it must be acknowledged, as discussed later, that occupational exposure may greatly exceed accepted safe levels.

#### Fetal Health Effects

Anesthetics have been implicated in the development of cancer, spontaneous abortions, and genetic and developmental anomalies. The possibility that chronic exposure to anesthetic waste gases could result in adverse health effects was first appreciated in the late 1960s, when a report of potential harm appeared in the Russian literature; Vaisman reported an increased incidence of abortions (18 spontaneous abortions in 31 pregnancies) among female anesthetists.[13] After this initial report, a multitude of retrospective studies followed. Of these, three large studies conducted during the 1970s and 1980s in the United States and the United Kingdom all concluded that the prevalence of spontaneous abortion was substantially higher in female anesthesiologists than in female physicians working outside the operating room.[14-17] Studies in this era also concluded that the incidence of congenital anomalies in children of male and female anesthesiologists was higher than in the control groups of physicians.[18-20] In addition to these reproductive effects, meta-analysis of six of these early studies linked the exposure to anesthetic gases to hepatic disease in male anesthesia personnel[21] and cervical cancer, liver disease, and kidney disease in female anesthesia personnel.[22] A number of studies with similar methodologies failed to detect a relationship between exposure and health.[23-25] Although many of these older studies suffered from significant methodologic limitations,[14,15,21] a 1997 meta-analysis of more than 19 studies completed between 1984 and 1992 reported a relative risk of abortion in female subjects exposed to anesthetic gases to be 1.48 (confidence interval [CI] 95%, 1.4-1.58).[26]

The Task Force on Trace Anesthetic Gases was convened by the American Society of Anesthesiologists (ASA) Committee on Occupational Health of Operating Room Personnel to analyze data from all available epidemiologic studies. The methodologic flaws in the studies impaired the task force's ability to draw conclusions about an association between occupational exposure to waste anesthetic gases and adverse health effects. Their report, published in 2002,[27,28] cited data from a prospective survey[29] of 11,500 U.K. female physicians documenting occupation, work practices, lifestyle, and medical and obstetric history, as well as hours of exposure and the use of scavenging equipment. This report showed the incidence of infertility, spontaneous abortion, and children with congenital abnormalities in female anesthesiologists to be the same as that in other physicians.[29] The position of the ASA is that "There is no evidence that trace concentrations of waste anesthetic gases cause adverse health effects to personnel working in locations where scavenging of waste anesthetic gases is carried out" and "the general conclusion… is that currently used anesthetics… have no mutagenic potential."[27,28] This reassurance may be of little comfort in light of evidence and clinical experience that show levels of exposure in clinical practice routinely exceed those considered safe by health and regulatory agencies.[4,5] The task force document also summarized contemporaneous recommendations from the Occupational Safety and Health Administration (OSHA) recommending that from the employee's "Right to Know," there are "potential adverse effects of exposure to waste anesthetic gases such as spontaneous abortions, and congenital abnormalities in children."[27,28]

Subsequently, there have been several more studies that support the possibility of an intrauterine effect. An analysis of Canadian nurses identified significant odds of congenital anomalies in the offspring of nurses working in settings with exposure to waste anesthetic gases compared with those working in settings where the likelihood of exposure was lower.[30] Subsequent research using chromosomal and molecular DNA analysis identified correlations between exposure and genotoxic effects (e.g., sister chromatid exchanges, breaks in DNA, and chromosomal abnormalities)[31-33] but did not examine clinical outcomes in offspring. However, these more recent epidemiologic and genetic studies did not quantify exposure but rather assumed exposure by selecting health care workers from settings where exposure was assumed to have taken place.

Given the study limitations, the lack of consensus or updated ASA guidelines, and the findings that safe inhalational anesthetic levels may often be exceeded, it must be acknowledged that harm is possible. Manufacturers of anesthesia work stations, health care systems, and clinicians must remain vigilant to reduce risk.

## Mitigating Health effects

The potential health effects of occupational exposure to anesthetic gas can be mitigated through waste anesthesia gas scavenging systems, establishing levels of safe exposure, auditing exposure levels, and enforcing recommended frequencies of air exchanges in locations where anesthesia gas may be found (e.g., operating rooms, procedural suites, and recovery areas).

Although the universal use of scavenging systems is critical to safe, modern anesthesia practice, it can lead to a false sense of security among operating room personnel. Kanmura and colleagues[34] found abnormally high ambient concentrations of $N_2O$ in 402 delivered anesthetics, of which 42% were the result of mask ventilation, 19.2% a disconnected scavenging system, 12.5% a leak around pediatric endotracheal tubes, and 11.5% equipment leakage. Furthermore, all of the scavenging system disconnects in this study were attributed to human error rather than equipment failure.[34] Because most anesthesia machines were not equipped to recognize disconnected scavenging systems, a fault that has been corrected on most modern anesthesia machines, a failure of the system on older machines may not be readily apparent. Diligent maintenance and a thorough understanding of anesthesia scavenging systems are essential to comply with NIOSH standards and to minimize operating room exposure. Emerging evidence exists for the role of various activated charcoal compounds to absorb molecules of anesthetic vapor,[35] but these have been trialed only in experimental settings and are not yet available commercially.

Regulations and recommendations regarding workplace safety are established by several governmental agencies. The OSHA is the national agency within the U.S. Department of Labor that sets and enforces standards to ensure "safe and healthful working conditions." The Centers for Disease Control and Prevention (CDC) and NIOSH are both federal agencies conducting research and making recommendations regarding health and workplace safety. Unlike OSHA, neither the CDC nor NIOSH are regulatory agencies. State and local health departments, as well as hospital infection control departments, are also tasked with enacting and enforcing health care workplace safety standards.

The NIOSH sets recommended exposure limits for the operating room setting, stating "no worker should be exposed … [to] concentrations greater than 2 ppm of any halogenated anesthetic or 25 ppm of $N_2O$" in the 1970s.[3] These exposure limits have not been updated nor do they include newer volatile anesthetic drugs. These exposure levels were selected based on the lowest level known at the time to cause side effects (50 ppm $N_2O$ or 1 ppm of halothane caused cognitive impairment in dental students)[36] and the level that could be easily and practically achieved.[37] Subsequently, it was realized that the data used to set the standards might not be generalizable because the subjects were Mormon, a subgroup likely more sensitive to depressant drugs[38]; a more recent study with a small sample size showed cognitive impairment at 50 ppm of $N_2O$,[39] levels that are routinely found in studies[4,5,40,41] and are well above the NIOSH levels. The threshold of perception of halothane ranges from less than 3 to more than 100 ppm.[2] If the anesthetic can be smelled, its concentration is likely to be many times greater than the maximum recommended level.

Occupational exposure is not limited to operating room staff, because patients continue to exhale trace amounts of $N_2O$ for 5 to 8 hours postoperatively.[42] Sessler and Badgwell used lapel dosimeters to measure the concentrations of volatile anesthetics of recovery room nurses during the first hour of PACU care in patients who had received inhaled anesthetics. In this study, breathing zone anesthetic

concentrations were in excess of NIOSH recommendations in 37% of patients who received isoflurane, 87% of patients who received desflurane, and 53% of patients who received $N_2O$.[43] A more recent but similar study reported a much lower average concentration (3.1 ppm) of $N_2O$ in the breathing zone of recovering patients in a Canadian PACU,[42] also above the recommended safe levels of exposure. These studies demonstrate the importance of proper ventilation in PACUs. Both groups reported PACU room air exchanges of 8 volumes per hour, although much of the air in the Sessler and Badgwell study was recirculated. $N_2O$ levels can be reduced to undetectable levels with air exchanges of 20 per hour, with 25% of each exchange taken from fresh air.[27] Although OSHA does not currently regulate exposure to $N_2O$ and halogenated anesthetics, the agency does provide guidelines designed to minimize workplace exposure. These include the appropriate assembly and monitoring of scavenging systems, the detection and correction of machine leaks, and the installation of effective ventilation systems.[44] In the operating room, the recommended air exchange rate is a minimum of 15 air exchanges per hour, with at least 3 air exchanges of outdoor air per hour. Laminar flow is better than turbulent flow with regard to measured levels of exposure.[4] In the PACU, at least 6 air changes are recommended, with a minimum of 2 exchanges of outdoor air per hour. OSHA recommends air sampling for anesthetic gases be performed on a biannual basis and records of air sampling methods, locations, dates, and concentrations measured, as well as results of anesthesia machine leak tests, be maintained for at least 20 years. Although OSHA is a government agency, these recommendations are not legally mandated.[27,28]

In summary, the possibility that waste anesthetic gas at levels routinely encountered in clinical practice could cause deficits in performance and human health remains. Caution must be exercised, and clinicians should limit their exposure as much as possible.

## RADIATION

The anesthesiologist is routinely exposed to both ionizing and nonionizing electromagnetic radiation. The former is primarily from x-rays and occasionally from radioactive isotopes that release gamma rays, and the latter is from lasers. Less common is contact with ionizing radiation from radioactive isotopes that release either alpha or beta particles. Ionizing radiation has enough energy to create both free radicals and ionized molecules in tissues by driving electrons completely out of their stable orbitals. If the radiation exposure is severe enough, tissues may be destroyed or chromosomal changes may cause malignant growth. Nonionizing radiation may excite electrons to move from the ground state to higher orbitals in molecules, but the electrons remain in the molecule. In this case, damage to tissues may result from the heat produced by the absorbed radiation.

### Ionizing Radiation: X-rays

In the past, exposure to radiation occurred mostly in the operating room with the use of portable fluoroscopy and x-ray machines. Advancements in endovascular surgery, hybrid cardiac surgery procedures, electrophysiology studies, and other imaging procedures significantly increase exposure of anesthesia personnel to ionizing radiation[45] relative to traditional operating room cases. Radiation is undetectable with our normal senses, so a basic understanding of its features will minimize exposure.

**TABLE 88.1** Relevant Exposure Limitations for X-Rays

| | OSHA* | | ICRP† | |
|---|---|---|---|---|
| Region | rem | mSv | rem | mSv |
| Head, eyes, gonads | 5 | 50 | 2 | 20 |
| Hands, wrists | 75 | 750 | 50 | 500 |
| Skin of the whole body | 30 | 300 | 50 | 500 |
| Pregnancy | 0.5 | 5 | 0.1 | 1 |

*Occupational Safety and Health Administration.[47]
†International Commission on Radiological Protection.[48]

One Sievert (Sv) is equal to 100 rem and is a measure of the biologic damage from radiation adjusted to apply to all tissues.[46] Estimates of radiation exposure from natural sources vary, depending on geographic location. The average in the United States ranges from 0.8 to 2 mSv (80-200 millirem [mrem]) per year. Natural radiation comes primarily from cosmic rays (approximately 0.4 mSv at sea level, with an increase of 0.1 mSv/1000 feet), as well as from radioactive compounds found in soil, brick, and concrete. For most physicians, the additional radiation from occupational exposure is no greater than that from natural sources. OSHA sets limits of occupational exposure (expressed as rem) that vary by body area; allowable limits are higher for the hands than for the whole body, gonads, or blood-forming parts of the body.[47] An easy rule of thumb is 5 rem (50 mSv) per year, with no more than 1.25 rem (12.5 mSv) in any given calendar quarter. In 2007 the International Commission on Radiological Protection, an international nonprofit, proposed more stringent limits than those proposed by OSHA (Table 88.1), and both agree that limits should be lower for personnel who are pregnant.[48,49]

Occupational exposure to radiation comes primarily from x-rays scattered by the patient and the surrounding equipment, rather than directly from the x-ray generator itself.[50] One chest radiograph results in approximately 25 mrem of exposure to the patient; procedures requiring multiple films occasionally involve more than 1 rem. The amount of radiation generated during fluoroscopy depends on how long the x-ray beam is on; just as light is reflected from surfaces, x-rays are reflected from the surfaces on which they impinge. This scattering accounts for most occupational exposure. Research findings vary about the degree of exposure typical for anesthesia providers, but most studies show low levels of exposure.[45,51-53] Recent studies have compared risk profiles of various positions of the anesthetist and the x-ray beam. A simulation-based study using phantom patient and anesthetist models with dosimeters demonstrated that exposure was greater near the head of the bed (vs. along the sides of the bed) or when the x-ray beam was in either of the lateral positions (e.g., shooting cross-table images).[54] A real-time evaluation of exposure in personnel conducting transesophageal echocardiography (TEE) during transcatheter aortic valve replacement showed that the TEE operator receives 5 times as much radiation as other

clinicians involved in the procedure.[55] Furthermore, this exposure is heightened by the use of oblique angles for imaging. Notably, by using additional shielding (e.g., a ceiling-mounted lead acrylic shield), this exposure was reduced by more than 80%.

### Mitigating Health Effects

Radiation physicists recommend the "As Low As Reasonably Achievable" guiding principle for radiation exposure to both the patient and practitioner. Technologic innovation leading to advances in imaging technology and industrial design may further limit exposure.[56,57]

Because the intensity of scattered radiation is inversely proportional to the square of the distance from the source, the best protection is physical separation. A distance of at least 3 feet from the patient is recommended. Six feet of air provides protection the equivalent of 9 inches of concrete or 2.5 mm of lead.[58] Using studies of real-time dosimeters and simulation studies using phantom patients, a recent systematic review found that at a 4.9-foot (1.5 m) distance from the x-ray source, exposure was no greater than that due to background radiation.[51] This finding has been replicated in a handful of studies of clinical exposures.[45,52] The authors go so far as to question the need for anesthesia personnel to wear lead aprons, which conflicts with OSHA recommendations.[59] Although they may be uncomfortable, aprons containing the equivalent of 0.25 to 0.5 mm of lead sheet are effective in blocking most scattered radiation and such devices are recommended to be worn whenever there is an exposure risk.[60] Uncovered areas, such as the lens of the eye, still bear the risk of injury,[50] and radiation dose to the eyes varies with the type of surgery and the position of the anesthesiologist relative to the patient and x-ray field.[54,61] OSHA recommends opaque goggles for health care workers in the "direct x-ray field."[59]

### Nonionizing Radiation: Lasers

Laser is an acronym for light amplification by stimulated emission of radiation. Lasers produce infrared, visible, or ultraviolet light. A surgical laser produces intense, focused electromagnetic radiation to cut or destroy tissues. Although the radiation from lasers is nonionizing, it is potentially unsafe both because of its intensity and because of the matter released from tissues during treatment.

Of those in common clinical use, carbon dioxide and neodymium:yttrium-aluminum-garnet (Nd:YAG) lasers emit light in the far-infrared and near-infrared wavelengths, respectively; argon and tunable dye lasers produce visible light.[62]

Eye injuries are the greatest risk to personnel working near lasers. Strict standards for protection have been developed based on current understanding but are subject to periodic revision. Either direct exposure or reflected radiation may cause eye damage. Injuries include corneal and retinal burns, destruction of the macula or optic nerve, and cataract formation. Protective eyewear is designed to filter out the radiation produced by a specific type of laser while still permitting vision. For example, clear plastic lenses block the far-infrared (10,600 nm) radiation from carbon dioxide lasers but provide no protection against the near-infrared (1064 nm) radiation emitted by Nd:YAG lasers. The type of protection provided by a given filter is marked on the frame of the goggles and should be checked before use. Filters that are scratched should not be used. Because certain filters block portions of the visible spectrum, it is prudent to confirm preoperatively that patient monitors can be seen and interpreted correctly with goggles in place. Protective eyewear is recommended for all exposed personnel because reflected radiation can be as hazardous as direct radiation and, unlike x-ray radiation, the intensity is not diminished significantly by the distance traveled in the average operating room.[62]

In addition to direct injury from laser light, clinicians should avoid the smoke plume created by lasers.[63-65] Under experimental conditions, viable bacteria have been recovered from the plume emanating from laser irradiation,[66] as have compounds known to be carcinogens and environmental toxins.[63] Intact DNA from human papillomavirus (HPV) has been detected in the vapor from both laser-treated plantar warts and genital condylomata[67,68] and on the gloves of treating physicians.[69] Human immunodeficiency virus (HIV) proviral DNA has been found in laser smoke produced by vaporizing cultures of HIV-positive cells.[70] Although these experiments, which used tissue cultures, do not replicate routine clinical circumstances, they stress the importance of strict attention to smoke removal. Simulation studies confirm that concentrations of laser-generated particulate matter are higher near the operating field than elsewhere in the room, sometimes by a factor of four, regardless of the degree of room ventilation.[64]

As an extreme example, a case report documented the appearance of laryngeal papillomas in a laser surgeon who had previously treated several patients infected with anal condylomata without the benefit of a laser smoke evacuator.[71] Tissue from the surgeon's laryngeal tumors contained HPV DNA types 6 and 11, the same viral types that are commonly harbored by anogenital condylomata. Hence it is prudent to scavenge all vaporized debris.

## SURGICAL SMOKE

Increasing attention is focused on the health effects of exposure to surgical smoke created by electrocautery and ultrasonic scalpels.[72] Data suggest that smoke from electrocautery contains infectious and malignant cells, albeit in small quantities, as well as carcinogenic compounds.[73] Ultrasonic scalpels can produce viable cells in the smoke plume, as demonstrated in a study that showed that the malignant cells grew cancer when subsequently injected into mice.[74]

Data from a NIOSH survey of health care workers shows that the majority of operating room personnel believe local exhaust ventilation devices (e.g., smoke evacuators on the surgical field) are not routinely in use.[75] Respondents reported that a lack of institutional protocols and a belief that exposure was minimal or not concerning were responsible for the lack of such protective strategies. Anesthesia personnel are intimately familiar with the various odors common in our practice; the smell of flesh burned with electrocautery should be a signal to those in the operating room that they are being exposed to potentially harmful material.

Mitigating the effects of exposure to surgical smoke is a critical endeavor. Most standard surgical masks trap only the largest of the smoke particles,[76] and standard surgical masks are demonstrably ineffective at filtering particles generated

**TABLE 88.2** Occupational Exposure, Risks, and Safety Measures

| Exposure | Sources | Potential Risks | Protection |
|---|---|---|---|
| Inhalational agents | Free gases<br>Mask inductions<br>Use of LMA<br>Agent spill<br>Inadequate scavenging | Infertility<br>Decrease in psychomotor performance<br>Cancer development<br>Spontaneous abortion<br>Hepatic disease<br>Congenital abnormalities | Scavenging systems<br>Air exchange<br>Use mask induction appropriately<br>Activated charcoal filters |
| Ionizing radiation | Portable fluoroscopy<br>Hybrid operating rooms<br>Interventional suites | Cancer<br>Eye damage<br>Infertility | Distance >3 feet from source<br>Lead aprons<br>Leaf shields<br>Lead surgical caps<br>Periodic radiation monitoring |
| Nonionizing radiation | LASER | Eye injury<br>Vaporization of bacterial or viral matter | Protective eyewear<br>Laser-specific surgical masks |
| Microdebris from smoke | Surgical cautery<br>Ultrasonic scalpel | Exposure to bacterial, viral, and carcinogenic matter | Surgical smoke evacuators<br>FFP 2 particulate masks |

by laser.[77,78] Even laser-specific masks were many-fold less effective at particle removal than the comparator, a protection class FFP level 2 dust and fine particle mask.[77] The median size of particles in plume samples obtained intraoperatively is 0.31 μm in diameter (range, 0.1-0.8 μm). Even after filtration of particles greater than 0.5 μm in diameter, exhaust smoke from tissues treated with a carbon dioxide laser causes pulmonary lesions in laboratory animals. If all particles larger than 0.1 μm are scavenged, no lung damage occurs, emphasizing the importance of scrupulous removal of the plume,[70,79] a practice advocated by the CDC, OSHA, and the Association of Perioperative Registered Nurses.

By using adequate evacuation and filtration equipment specifically designed to scavenge such vapors, it may be less likely that operating room personnel will be contaminated by laser-dispersed HPV DNA.[67] However, laser-specific surgical masks should also be used whenever lasers are in use, and institutions should evaluate the use of smoke evacuators for the surgical field (Table 88.2).

## Infectious Exposures

Understanding the basic principles of infection control is essential to the safe and responsible practice of anesthesia.

### INFECTION PRECAUTIONS

Infection control standards have changed dramatically over the past 50 years, with the introduction of protocols for handwashing, use of personal protective equipment (PPE), incorporation of environmental controls, and implementation of sharp safety devices.

Beginning in 1985 in response to the HIV/AIDS epidemic, the CDC released recommendations for "universal precautions" to be used by all health care workers exposed to blood or body fluids, regardless of the infectious status of a patient.[80] These recommendations were expanded in 1996 into the concept of standard precautions (SP), which are to be used with all patients at all times. The CDC also introduced airborne, droplet, and contact transmission-based precaution guidelines for diseases spread by those specific routes.[80]

#### Standard Precautions

SP encompass hand hygiene between every patient contact event, before aseptic tasks, and after contact with bodily fluids. Hand hygiene includes both the use of plain or antibacterial soap and water and the use of alcohol-based gels without water. Unless hands are visibly soiled, hand hygiene with an alcohol-based gel has greater antimicrobial effect and is preferred to soap and water.[81] It is estimated that every anesthesia procedure presents at least 25 hand hygiene opportunities and hundreds of contact events with the patient and then surfaces in the anesthesia environment but that anesthesiologists are compliant with hand hygiene recommendations only approximately 1% to 10% of the time.[82,83] Importantly, using gloves does not obviate the need for hand hygiene, because 1% to 2% of examination gloves have microperforations that can allow bacteria to penetrate the glove surface.[84]

SP include the application of PPE such as a gown, gloves, a mask, or eye protection as appropriate during patient-care activities likely to expose a health care worker to a patient's blood or secretions. The need for PPE differs depending on the specific task at hand. During intubation, it is recommended that the anesthesiologist perform hand hygiene and use gloves, a mask, and eye protection.[85] One study estimated the frequency of glove use by anesthesiologists during intubation, extubation, and IV line placement at only 10% for attending anesthesiologists and 50% for trainees.[86]

When a patient is known or suspected to have an infection transmitted by a specific route, such as contact, airborne particles, or droplets, specific transmission-based precautions should be used in addition to SP. These precautions are discussed in more detail later.

When transporting a patient on transmission-based precautions, it is important to ensure that the infectious areas of the patient are appropriately contained. For example, if a patient is on airborne precautions for active TB, then the patient should wear an N95 mask or higher during transport. If a patient is on contact precautions, the patient should be covered in a gown or sheets and providers should wear clean PPE during transport.[80]

**TABLE 88.3** Immunizations Recommended for Health Care Workers

| Infection | Risk to Health Care Workers | Immunization | Special Considerations |
|---|---|---|---|
| Hepatitis B | Percutaneous or mucosal exposure to infectious blood/body fluid | 3-dose series at 0, 1, and 6 months | Approximately 1% receiving the complete series will not have full immunity |
| Influenza | Infectious transmission via droplet route | Yearly | Effectiveness of vaccine varies with year |
| Measles, mumps, rubella | Infectious transmission through droplet and airborne routes | 2-dose vaccine for measles, mumps and rubella together (usually as a child) | 1% of health care workers who were vaccinated may have lost immunity |
| Pertussis | Contact or droplet transmission | Every 10 years (usually as Tdap with tetanus and diphtheria toxoids) | Even immunized health care workers need postexposure prophylaxis |
| Varicella | Contact or airborne transmission | 2-dose series (not needed if history of past varicella infection) | |

Information from Immunization of health-care personnel, recommendations of the Advisory Committee on Immunization Practices (ACIP), Centers for Disease Control and Prevention 2011- REF 20.

### Environmental Controls

Environmental controls are additional safety measures used to prevent the spread of airborne infectious particles; examples in hospitals include engineering systems to manage ventilation (e.g., negative pressure rooms), use of high-efficiency particulate air (HEPA) filtration, frequent air exchange rates, and ultraviolet irradiation of air in the upper portion of a room or in air ducts.[87,88] Because operating rooms are kept at positive pressure with respect to hallways (to prevent the introduction of infectious particles into a sterile area), elective procedures on patients with active TB or other airborne diseases should be postponed. If it is not possible to delay surgery, the procedure should be performed in an operating room with an anteroom.[89] A HEPA filter should be placed in the circuit after the Y-connector, to prevent contamination of the anesthesia machine.

### Needlestick and Sharps Safety

A key element of universal precautions and SP is the prevention of injuries due to sharps and the use of safe injection practices. In 2000 the CDC estimated that health care workers experience more than 600,000 needlestick and other percutaneous injuries yearly.[90] OSHA has developed standards to protect health care workers from exposure to bloodborne pathogens. These standards were most recently updated in 2001 after the passage of the federal Needlestick Safety and Prevention Act of 2000.[91] OSHA standards mandate that employers make available safety-engineered sharps devices, provide for safe disposal of sharps, make appropriate PPE available, offer free hepatitis B virus (HBV) vaccination to workers who have been exposed to potentially infectious fluids, and have procedures for medical evaluation and PEP for employees exposed to bloodborne pathogens.[92] With the implementation of safety-engineered sharps, overall needlestick injury rates have dropped significantly from before 2000 to after 2004, in some studies, by well over 50%.[93]

The risk of a sharps injury correlates with medical specialty and clinical experience. The Duke Health and Safety Surveillance System Study quantified the risk of percutaneous exposures to body fluids by various health care worker groups. In this study, anesthesia residents had 19 needlestick events per 100 residents per year, compared with an exposure rate for all anesthesia providers of 6.9 events per 100 employees per year and an overall exposure rate of 3.9 events per 100 full-time employees.[94] In addition, night work and shifts lasting greater than 24 hours were associated with an increased rate of needlestick injury.[95]

Injuries from the use of hollow-bore needles account for more than half of sharps injuries.[90] Percutaneous injuries can occur during and after use of a sharp device. Wearing gloves, double gloving, and avoiding recapping needles by using a two-handed technique can reduce the risk of a needlestick injury.[90,96] In addition, the use of a curved suture needle with a needle holder for suturing is safer than the use of a handheld straight suture needle.[97]

Accidental needlesticks are underreported. The CDC estimates that only approximately 54% of percutaneous exposures are reported to occupational health, perhaps because of fears that reporting will be time consuming or nonconfidential.[98] All occupational needlesticks and exposures should be reported to a hospital occupational health program for evaluation, testing, and possible PEP.

### Vaccine Preventable Illness

The CDC Advisory Committee on Immunization Practices recommends that all health care providers be vaccinated against a variety of vaccine-preventable diseases to reduce the risk of occupational exposure and transmission of these pathogens (Table 88.3).

The most up-to-date infection control guidelines are available at the CDC website.[99] Recommendations for infection control specific to the practice of anesthesia have been published by the ASA Committee on Occupational Health Task Force on Infection Control.[6]

## TRANSMISSION OF INFECTIOUS AGENTS

Anesthesia providers are exposed to a wide range of infectious pathogens, including bacteria, viruses, fungi, parasites, and prions. The three principle routes of pathogen transmission are via contact, droplet, and airborne spread. Bloodborne infectious agents, such as HIV and HBV, are transmitted to the health care worker via percutaneous injuries or direct contact of nonintact skin or mucous membranes with infected blood or other serum derived body fluids (Table 88.4).[100,101]

### Contact Transmission

Contact transmission, the most common type of infectious transmission,[80] can either be direct, from an infected person to another person, or indirect, with a contaminated

**TABLE 88.4** Infectious Precautions for Selected Transmissible Diseases*

| Infection | Type of Infectious Precaution | Special Considerations |
|---|---|---|
| AIDS/HIV | Standard | Standard precautions include needlestick safety. Postexposure prophylaxis indicated for some exposures |
| Aspergillosis | Standard | |
| *Clostridium difficile* | Contact | Handwashing is required after patient contact, spores are not removed with alcohol-based gels |
| Ectoparasites (i.e., lice, scabies) | Contact | |
| Gastroenteritis | Standard | Contact precautions if rotavirus, or if the patient is diapered or incontinent |
| Hepatitis (A-E) | Standard | Postexposure prophylaxis may be indicated for HBV percutaneous exposure |
| Herpes simplex<br>Severe primary mucocutaneous<br>All other infections (including encephalitis) | Contact<br>Standard | Until lesions are dry and crusted |
| Herpes zoster (Varicella-zoster)<br>Local<br>Disseminated | Standard<br>Airborne, Contact | Nonimmunized health care workers should not enter room if immunized caregivers are available. |
| Influenza | Droplet | Postexposure prophylaxis may be indicated in some circumstances |
| Measles | Airborne | Nonimmunized health care workers should not enter room if immunized caregivers are available. |
| Meningococcal disease | Droplet | Postexposure prophylaxis may be indicated in some circumstances |
| Mumps | Droplet | Nonimmunized health care workers should not enter room if immunized caregivers are available. |
| Multidrug resistant organisms (including MRSA, VRE, ESBLs) | Standard or Contact | Contact precautions are recommended in settings with evidence of ongoing transmission, acute care settings, or wounds that cannot be contained by dressings |
| Pertussis | Droplet | Postexposure prophylaxis may be indicated in some circumstances |
| Prion diseases | Standard | Use special sterilization procedures for contaminated surgical equipment |
| Respiratory syncytial virus | Contact | Use mask for actively coughing patient according to standard precautions |
| Rhinovirus | Droplet | |
| Rubella | Droplet | Nonimmunized health care workers should not enter room if immunized caregivers are available. |
| Severe acute respiratory syndrome (SARS) | Airborne, Droplet, Contact | |
| Staphylococcus (excluding MRSA)<br>Major draining wounds<br>Minor wounds or infections | Contact<br>Standard | |
| Streptococcus (group A) | Droplet<br>Contact-only for major wounds | Droplet if major infectious, involves the respiratory tract. Standard precautions if a minor or limited infection |
| Tuberculosis (active)<br>Pulmonary<br>Extrapulmonary | Airborne<br>Airborne, Contact* | Contact if active draining lesions present |
| Viral hemorrhagic fevers (including Ebola, Marburg, Lassa) | Droplet, Contact, and Airborne | |

*Excerpted from Appendix A. Type and duration of precautions recommended for selected infections and conditions. Centers for Disease Control and Prevention (CDC) 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings.[80]
*HBV*, Hepatitis B virus; *MRSA*, methicillin-resistant *Staphylococcus aureus*.

intermediate such as a laryngoscope handle in an operating room.[102] When a patient has a contact-transmitted infection, contact precautions should be used at all times. These include keeping patients separated at least 3 feet from neighbors and wearing a gown and gloves for all patient-care interactions. Examples of microorganisms commonly transmitted via contact include respiratory syncytial virus, herpes simplex virus, *Staphylococcus aureus* (including methicillin-resistant *S. aureus*), and scabies.[80]

*Clostridium difficile* is an epidemiologically important contact-transmitted organism in health care facilities. *C. difficile* is a gram-positive spore-forming anaerobe that causes diarrhea and pseudomembranous colitis. The use of broad-spectrum antibiotics such as cephalosporins, clindamycin,

and vancomycin are associated with *C. difficile* infection. Notably, *C. difficile* spores are not removed by the use of alcohol-based hand disinfectants. Health care workers who are in contact with patients suspected of having *C. difficile* infection should use contact precautions at all times and wash hands with soap and water after patient contact.[80]

Norovirus, a single-stranded RNA virus, is an important contact-transmitted organism and the most common cause of acute gastroenteritis in health care settings.[103] Health care workers should use standard and contact precautions any time a patient presents with diarrheal symptoms. Health care workers who contract norovirus should check with their institutional policy, which may require that the worker be excluded from work for at least 24 hours after symptoms have resolved.[103]

Parasitic skin diseases caused by lice and scabies are also spread via contact transmission. Anesthesiologists should be aware of the highly contagious nature of these conditions and use a gown and gloves for all interactions with patients who have an undiagnosed rash or are suspected of carrying ectoparasites. PEP is not routinely recommended.[104]

## Droplet Transmission

Droplet transmission occurs when an infectious agent travels a short distance directly from the respiratory tract of an infected source to a susceptible mucosal surface in a recipient.[80] Droplet transmission can occur during intubation, airway suctioning, or if the patient coughs or sneezes.[105] The risk of droplet transmission is believed to be greatest at a distance of less than 3 feet from an infected person. For this reason, appropriate PPE precautions for patients with droplet-transmitted infections include keeping patients separated at least 3 feet from neighbors and wearing a mask for all close patient contact.

Microorganisms commonly transmitted via droplets include influenza and other respiratory viruses, group A streptococcus, and *Neisseria meningitidis.*[80]

Influenza virus types A and B cause respiratory illness in humans, ranging from mild to severe disease (influenza A infection generally causes more severe disease). Subtypes of influenza A virus are named for the surface antigens they display: H (hemagglutinin) and N (neuraminidase). Because these surface antigens change over time (termed antigenic drift), protective immunity from prior exposure to the influenza virus is partially lost. More infrequently, the surface antigens can change significantly (antigenic shift) and cause pandemic disease because the population has no immunity against the new virus strain. A pandemic H1N1 influenza A strain in 2009 caused illness in an estimated 60 million Americans.[106]

Because influenza virus subtypes change yearly, the CDC recommends that all persons older than 6 months be vaccinated yearly.[107] The influenza vaccine cannot cause influenza infection.[107] Anesthesiologists are at particular risk for exposure to influenza because of close contact with nasopharyngeal secretions. Increasingly, health care organizations are making yearly flu vaccination a mandatory condition of medical credentialing.[108]

Pertussis, a respiratory illness caused by *Bordetella pertussis*, and invasive meningococcal infections caused by *N. meningitidis* are two droplet-transmitted infections for which PEP is recommended for exposed health care workers.[80,105] Because intubation and suctioning are considered high-risk exposures to these infections, even vaccinated anesthesiologists should be aware of the need for chemoprophylaxis if they are involved in the care of infected patients.[24] The CDC recommends 5 to 7 days of macrolide therapy for pertussis exposure and single-dose oral ciprofloxacin or intramuscular ceftriaxone for exposure to invasive meningococcal disease.[109,110]

Droplet transmission of oral flora from health care workers to patients during lumbar puncture where the provider was not wearing a face mask has been implicated as a cause of bacterial meningitis.[80,111-113] Anesthesia providers should wear face masks when placing invasive catheters or needles, including into the spinal, epidural, or central venous spaces to reduce the risk of droplet transmission of infectious agents.

## Airborne Transmission

Airborne transmission occurs when infectious particles are carried in the air and remain infective over time and distance, such as when infected droplets dry into much smaller particles called droplet nuclei or when small infectious particles (i.e., spores) are created. These small (<5 μm particles) are more likely to travel into the lower respiratory tract and cause severe infection. Patients with suspected airborne infections should be placed in a negative pressure rooms with specific air filtration requirements. All health care workers taking care of patients on airborne precautions should wear N95 or higher-level respirators.[80,87] These respirators must filter particles of 0.3 μm or greater in size with at least 95% efficiency. A tight mask fit is essential to proper mask function, and for this reason employers are required to perform respirator mask fit testing during employee training and periodically thereafter.[88]

Microorganisms transmitted via the airborne route include *Mycobacterium tuberculosis (TB)*, rubeola virus (causing measles), and varicella-zoster virus (causing chicken pox).[80]

TB is the result of infection with *M. tuberculosis*, an acid-fast bacillus that has caused disease in humans for more than 4000 years. Infection with *M. tuberculosis* occurs when a person inhales small infected airborne particles containing the bacterium. These particles, called droplet nuclei, are 1 to 5 μm in size and can remain airborne for prolonged periods, spreading throughout a room or building.[88] The risk of infection with *M. tuberculosis* varies with proximity to a source and duration of exposure. Anesthesiologists are at particularly high risk for TB exposure because bronchoscopy and endotracheal intubation have been reported as the two highest-risk procedures leading to skin test conversion in health sector workers.[89,114]

In otherwise healthy individuals who have been infected with *M. tuberculosis*, the disease is usually contained by the immune system in 2 to 12 weeks, when immunologic tests for TB will become positive,[88] although the bacteria can remain in the body for years, a condition referred to as latent TB. Latent TB is asymptomatic and is not infectious. Five to 10% of people who are infected with *M. tuberculosis* go on to develop active TB over the course of their lifetime.[115] The risk of developing active TB after infection with *M. tuberculosis* is much higher in those with a compromised immune system, such as persons with HIV or diabetes or undergoing

immunosuppressive therapy.[88] Although most TB is curable if properly treated, untreated TB can lead to death in more than 50% of cases within 5 years.[35] Currently, the World Health Organization estimates that 1.7 billion people, approximately one-fourth of the world's population, are infected with *M. tuberculosis.*[115] Ninety-five percent of TB cases and deaths occur in developing countries.

In the United States, there were 9287 new cases of TB reported in 2016, with an incidence of 2.9 cases per 100,000 persons.[116] The incidence of TB in the United States has been declining after a surge in the 1990s, related to infection control measures put in place by the CDC.[88] All health care settings must have a TB infection-control program to identify and treat persons with TB, educate and screen health care workers at risk for contracting TB, develop environmental controls such as isolation rooms and negative pressure ventilation systems, and implement respiratory protection programs to reduce health care worker exposure risk.[88]

The commonly used tuberculin skin test (purified protein derivative) provides a qualitative measure of TB exposure. A newer quantitative test for TB is available that can test for atypical organisms but requires a blood sample.[88] All health care workers at high risk for exposure to TB should be skin tested at the time of employment and retested annually for a new exposure. A two-step test is recommended for anyone who tests negative more than 1 year after a prior test or TB exposure because latent TB infections can result in initial false-negative results from waning of the delayed type hypersensitivity response. The first test will "boost" the response, leading to a positive result with the second test in those with a true exposure.[88]

Health care workers who have a newly positive tuberculin skin test need to be screened for active TB with a clinical evaluation and a chest radiograph. If active TB is diagnosed, treatment according to recommended guidelines should begin immediately. Disease reporting laws generally require notification of local or state health departments within 24 hours of an active TB diagnosis. If active disease is excluded, drug therapy for latent TB infection is recommended for health care workers, in consultation with occupational health and infectious disease physicians. Standard drug regimens for treatment of latent TB are 6 to 9 months of isoniazid or 4 months of rifampin.[88] Those with a previous history of liver injury may not be good candidates for treatment of latent TB infection. Latent TB is not infectious, even if untreated, and should not preclude the anesthesiologist from engaging in patient care.

### Complex Transmission

Microorganisms are commonly transmitted by more than just one route. For example, respiratory syncytial virus is most commonly transmitted via contact but can also be transmitted via droplets,[80,117] necessitating health care workers to use PPE to guard against both forms of transmission. Therapies commonly used for respiratory support, such as noninvasive positive pressure ventilation, have been implicated in the aerosol dispersion of respiratory diseases such as influenza.

Aerosol dispersion of infectious particles normally transmitted via droplet or contact transmission was a hallmark of the severe acute respiratory syndrome (SARS) viral outbreak that occurred between 2003 and 2004. SARS was a respiratory disease with a reported 6% mortality rate.[80] In some centers, up to 50% of the cases of SARS were in health care workers who had cared for patients with SARS.[25] Endotracheal intubation, tracheal suctioning, and care for patients on noninvasive positive pressure ventilation were identified as risk factors for health care worker infection.[80,105,118]

**TABLE 88.5** Bloodborne Pathogens

| | Risk of Seroconversion After Percutaneous Exposure* | Progression to Chronic Disease |
|---|---|---|
| Hepatitis B | 6-30%** | 5% of immunocompetent adults |
| Hepatitis C | 0.5-2% | 75-85% |
| HIV | 0.3% | 100% |

*Risk varies depending on type of exposure and infectivity of the host.
**In those without serologic immunity.
Risks of seroconversion are related to: depth of exposure, viral load of patient, type of exposure (hollow-bore needle highest risk), presence of visible blood on the needle.

### Bloodborne Organisms

Anesthesiologists are at constant risk of needlestick or other sharps injuries or injuries where blood or other serum-derived fluids from a patient could come in contact with nonintact skin or mucosal surfaces. The risk that accidental exposure to blood or body fluids will result in infectious transmission varies with the type of exposure (percutaneous being the highest risk), the instrument of exposure (hollow bore needles are higher risk than suture needles), the depth of needle penetration, the infectious agent, and the quantity of infectious particles a health care worker is exposed to. After an occupational exposure, the area should be washed with soap and water. Use of antiseptics or attempting to express fluid from the wound site has not been shown to be effective at reducing the rate of infectious transmission.[119] PEP may be recommended to reduce the risk of seroconversion. HBV, hepatitis C virus (HCV), and HIV are the three bloodborne infectious agents that pose the greatest occupational risk to the anesthesiologist (Table 88.5).[85]

HBV is a cause of acute viral hepatitis that is acquired by percutaneous or mucosal contact with infected blood or body fluids. Importantly, HBV can survive outside of the body for up to 7 days, and even needles without any visible blood can be infectious.[119,120] In unvaccinated individuals, the risk of seroconversion after percutaneous exposure to HBV varies from 6% to 30%, depending on the infectivity of the source and the type of contact with serum.[121,122] More than 50% of acute infections are asymptomatic, but signs of acute infection include fever, jaundice, fatigue, and abdominal pain. Rarely, acute HBV infection can lead to fulminant hepatitis. In adults, the virus is cleared completely after initial infection in up to 95% of cases.[120] However, chronic HBV can cause cirrhosis and hepatocellular carcinoma. Liver disease is the cause of death in 25% of those chronically infected with HBV.[120]

In the United States, there are approximately 20,000 new cases of HBV infection per year and an estimated 850,000 to 2.2 million people living with chronic hepatitis B infection.[123] Globally, there are nearly 900,000 HBV-related

deaths every year. Before the introduction of a hepatitis B vaccine in the 1980s, HBV was a significant occupational hazard for anesthesiologists. One multicenter study of anesthesia residents in the 1980s found that 17.8% of 267 tested residents showed serologic evidence of exposure to HBV.[124] The availability of a vaccine has dramatically changed the epidemiology and occupational risk of HBV. The number of HBV infections in health care workers declined by 98% between 1982 and 2010.[119]

Health care workers are strongly encouraged to complete a series of three injections of hepatitis B vaccine. OSHA requires that health care facilities provide the vaccine free of cost.[125] Those who refuse hepatitis B vaccination must sign a statement declining the vaccine. Because immunity can wane over time and some people do not respond completely to the series, serologic testing for anti–hepatitis B surface antigen after vaccination and revaccination if immunity is not present may be part of an occupational health strategy at many hospitals.[119]

In the case of an accidental exposure, the source patient, if known, should be tested for HBV, in accordance with laws regarding informed consent. In those health care workers who have had a three-dose vaccine series and who have documented immunity by serologic testing, there is no need to test the source patient for HBV and no postexposure management is necessary.[119] If the health care worker does not have evidence of serologic immunity, the worker should be tested for immunity. In those without immunity and those who have not been vaccinated, hepatitis B immune globulin (HBIG) can be administered as PEP, together with the hepatitis B vaccine, if indicated.[119] HBIG will provide temporary protection from HBV for 3 to 6 months.[119]

HCV, like HBV, is a bloodborne virus that causes acute viral hepatitis. However, unlike HBV, HCV is not transmitted efficiently through percutaneous exposure to infected blood. The incidence of seroconversion after accidental percutaneous exposure to HCV varies but is estimated to be between 0.5% and 2%.[126] Of those who are exposed to HCV and develop acute infection, the infection is cleared in only 15% to 25% of cases.[126] The majority of infections progress to a chronic stage, and 5% to 20% of infections cause cirrhosis over the long term.[126]

In the United States, there were 2967 cases of acute HCV reported in 2016. Three to 4 million people in the United States have chronic HCV.[123] Unfortunately, there is no vaccine or PEP available for HCV, but there are effective treatments, including direct-acting antiviral agents, which can lead to complete clearance of infection in more than 90% of patients who are treated.[127]

Because HCV is treatable, health care workers who have an accidental exposure to HCV should be tested for anti-HCV within 48 hours of an exposure. All those tested without evidence of prior exposure should have repeat HCV RNA testing 3 weeks or greater from the time of initial exposure. If there is evidence of HCV infection, the health care worker should be referred for expert monitoring and treatment, if the primary infection is not cleared.

Accessing multidose vials for multiple patients, particularly propofol vials, has been linked to the transmission of HBV and HCV in many health care–associated outbreaks. In a 2006 high-profile case, five cases of HBV and six cases of HCV were linked to a single anesthesiologist at an endoscopy center, who was found to have used a syringe that had been in contact with a chronically infected patient to access a multiuse propofol vial, contaminating it.[128] Subsequent use of the propofol vial in other patients resulted in the transmission of HBV and HCV. Safe injection practices are part of standard infection precautions. The CDC recommends that vials should never be entered with a used syringe, even with a new needle or cannula. Medication vials in the immediate patient treatment area should always be single use.[80,85]

HIV is an RNA retrovirus that is spread through blood or serum-derived fluid. Once introduced into a host, HIV binds to cells with a CD4+ surface antigen (such as helper T lymphocytes) and replicates by integrating its viral DNA into the host cell DNA to establish a persistent infection.[129] According to statistics from the Joint United Nations Program on HIV/AIDS, in 2016 there were approximately 36.7 million people with HIV, with the most affected region being sub-Saharan Africa. HIV is mostly transmitted from person to person through unprotected anal or vaginal intercourse. HIV can also be transmitted from mother to child or through sharing or accidental exposure to an HIV contaminated needle.

If a health care worker has a percutaneous exposure to HIV, the risk of infectious transmission is low, approximately 0.3%. The risk of transmission after mucous membrane exposure (such as being splashed in the eyes or mouth with infected blood) is even lower (approximately 0.09%).[130] Injuries from patients with higher viral loads, use of hollow-bore needles, and deeper injuries are more likely to lead to HIV transmission.

The acute phase of HIV infection follows 3 to 6 weeks after exposure, with a nonspecific, febrile viral syndrome similar to influenza infection or mononucleosis that lasts 2 to 6 weeks.[129] The infection then enters an asymptomatic phase that can last for many years before the appearance of signs of immunodeficiency. Antibody screening tests for HIV will be positive in most patients by 8 weeks after the initial infection.[129]

After a high-risk exposure to an HIV-infected patient, health care workers should immediately contact their onsite occupational health department for postexposure management. The Clinician Consultation Center PEPline service offers free clinician advice on the risk of disease transmission and initiation of PEP.[130] Following an accidental occupational exposure, the source patient should be tested for HIV status with a rapid HIV test, observing local regulations regarding consent for HIV testing. Rapid HIV tests are considered sensitive and specific enough by the CDC to determine the need for PEP without additional testing.[131]

PEP with antiretroviral drugs is available and is most effective when given as soon as possible after the exposure, usually within 72 hours.[50] The decision to use PEP is nuanced and is based on the likelihood of exposure (i.e., if the source is known to have HIV, PEP is more strongly recommended versus if the source has an unknown status or the exposure was from an unknown source such as a sharps box). PEP can always be started and then discontinued after more information is obtained or expert consultation is available. A full course of PEP most commonly consists of a 28-day, three-drug antiretroviral regimen of tenofovir, emtricitabine, and raltegravir or dolutegravir. The most common side effect of

PEP is gastrointestinal upset, with fatigue, headache, and insomnia also contributing to poor PEP adherence. Tenofovir can cause renal toxicity and is relatively contraindicated in those with impaired renal function.

Regardless of whether PEP is initiated, the CDC recommends reevaluating exposed health care workers within 72 hours and, at a minimum, follow-up HIV testing of the exposed health care worker at 6 weeks, 12 weeks, and 6 months after exposure.[131] A systematic review of PEP found that the risk of HIV infection was 89% lower among animals receiving PEP after an exposure to HIV than those who did not receive PEP.[132] One small retrospective study of the use of zidovudine alone for PEP in health care workers exposed to HIV showed that the use of PEP resulted in a risk reduction of 81% for HIV seroconversion.[133]

### Emerging Diseases

Occasionally, novel or previously nonvirulent infectious agents shift or become more pathogenic, creating anxiety and uncertainty among the public and the health care sector. In the presence of such outbreaks, medical centers must have plans and procedures in place to contain infectious agents, educate workers, and protect them from infection.

Prion diseases, caused by abnormal pathogenic agents able to induce misfolding of normal cellular proteins in the brain, lead to an incurable progressive neurodegenerative disease that usually results in death within 1 year of symptom onset. Creutzfeldt-Jakob disease (CJD), which caused approximately 500 deaths in the United States in 2016, is sporadic or familial in 95% of cases.[134] However, there have been occurrences of iatrogenic transmission of CJD through human-derived growth hormone, dural and corneal grafts, and the use of contaminated neurosurgical equipment.[80] Fortunately, since the implementation of routine sterilization practices, there have been no equipment-related cases[135] and, in the United States, no cases have been linked to percutaneous exposure or bloodborne transmission.[80] Variant CJD (vCJD) is a separate degenerative disorder caused by the same agent responsible for bovine spongiform encephalopathy (mad cow disease) in cows. vCJD transmission has largely been linked to the ingestion of contaminated meat in the United Kingdom; however, there were two reported cases of bloodborne transmission of vCJD.[80] SP should be used when caring for patients with suspected or confirmed prion disease. There are special guidelines for the reprocessing of surgical equipment used in patients with prion disease available through the World Health Organization.

Ebola is one of a group of viruses, including Marburg, Lassa, dengue, and yellow fever, that causes viral hemorrhagic fever syndromes.[80] Between 2014 and 2016, and again in 2018, in West Africa there were outbreaks of Ebola virus disease (EVD), with at least 28,652 cases of Ebola and 11,325 suspected deaths.[135a] EVD is transmitted readily to health care workers and is acquired through direct contact (through broken skin or mucus membranes such as the eyes, nose, or mouth) with blood or body fluids from an infected person but not via aerosol droplets.[80] The CDC recommends that all health care workers caring for patients with EVD use an N95 mask or higher respirator in addition to full contact and droplet precautions, to prevent accidental exposure of a mucus membrane to contaminated body fluid. Health care workers caring for patients with viral hemorrhagic fevers should go through special training on donning and doffing PPE, supervised by a trained observer to ensure that equipment is safely removed without contaminating the surrounding area.

## Substance Use Disorders

Medical personnel treat patients suffering from substance use disorders (SUDs) every day. The psychiatric and social impacts are evident. Associated medical conditions such as HCV, HIV, bacteremia, and endocarditis require the highest level of care. Health care workers are not spared from this family of diseases. The Accreditation Council for Graduate Medical Education (ACGME) Common Program Requirements state that residents in anesthesiology understand their role in the recognition of impairment; however, recent work by Warner and associates has demonstrated that the problem may in fact be increasing and that the lives of promising young physicians are lost every year due to the use of drugs.[136,137] Some of the factors thought to lead to SUDs in health care personnel include access to potent substances, exposure to a high stress environment, long hours, variable shifts, and a culture of self-medication. Detection of SUDs is difficult because work may be the last area to suffer. Self-policing has been the main mode of detection, but organizations are currently incorporating more objective measures such as surveillance of medical records and drug testing. Timely and compassionate intervention is critical when an individual is suspected of performing under conditions of impairment, especially with SUDs, which threatens the safety of the resident, as well as that of the patient. Comprehensive treatment is critical for those diagnosed with an SUD.

### EPIDEMIOLOGY

The incidence of SUDs including alcohol abuse among anesthesia personnel is the same as that in the general population, 10% to 20%. The incidence of misuse, abuse, or dependence on drugs other than alcohol among anesthesiologists has remained consistent over the years, at 1% to 2%.[138-141] A survey of Canadian residency program directors revealed a similar rate among residents, at 1.6%.[142] Bell and associates surveyed 2500 practicing nurse anesthetists and reported an incidence of 9.8%.[143] A lower rate was reported for fellows (0.4%). The problem of SUDs among anesthesia personnel is not limited to the United States, because studies in Australia, New Zealand, and Brazil[144] document similar results.[145-147]

The most common substance misused by anesthesia personnel has traditionally been opioids, as indicated in multiple studies (Table 88.6).[137-140,145-147] Over the past several years there has been an increase in the abuse of other drugs, including propofol, ketamine, and remifentanil, as well as volatile anesthetics.[148]

Since its introduction in 1986, the incidence of propofol abuse appears to be increasing. In a 2007 survey of 126 academic anesthesiology training programs, Wischmeyer and associates[149] reviewed 25 cases of propofol abuse and determined an incidence of 0.1% per decade, a fivefold increase from a previous study by Booth et al.[140]

**TABLE 88.6** Most Common Drugs of Abuse

| Study (Year) | Cohort (Years) | Most Used Substances |
|---|---|---|
| Ward (1980) | 289 anesthesiology programs in United States<br>1970-1980 | Meperidine<br>Fentanyl<br>Morphine<br>Diazepam<br>Other<br>Alcohol |
| Menk (1990) | 159 anesthesiology programs in United States 1975-1989 | Parenteral opioids<br>Diazepam<br>Alcohol<br>Inhalational agents |
| Weeks (1993) | Anesthesiology training programs in Australia and New Zealand<br>1981-1991 | Opioids<br>Cannabis<br>Cocaine<br>Alcohol<br>Benzodiazepines<br>Barbiturates |
| Bell (1999) | 2500 Actively practicing certified registered nurse anesthetists in United States<br>1999 | Benzodiazepines<br>Propofol<br>Inhalational agents<br>Opioids<br>Dissociative drugs (ketamine) |
| Booth (2002) | Academic anesthesiology programs<br>July 1990-July 1996 (residents)<br>July 1990-June 1997 (staff) | Fentanyl<br>Sufantanil<br>Cocaine<br>Nitrous oxide<br>Meperidine<br>Midazolam<br>Diazepam<br>Ketamine<br>Halothane<br>Propofol<br>Others |
| Fry (2005) | Anesthetists in Australia and New Zealand (128 anesthesiology departments)<br>1994-2003 | Opioids<br>Induction agents<br>Benzodiazepines<br>Alcohol<br>Inhalational agents |
| Palhares-Alves (2012) | Anesthesiologists treated in a reference program in Brazil<br>2002-2009 | Opioids<br>Benzodiazepines<br>Alcohol<br>Marijuana<br>Amphetamines<br>Cocaine/Crack |
| Warner (2013) | Anesthesiology training records from ABA, DANS, NDI<br>1975-2010 | Opioids<br>Alcohol<br>Marijuana/Cocaine<br>Benzodiazepines<br>Propofol |
| Fry (2015) | Australian and New Zealand anesthesia trainees<br>1981-2013 | Opioids<br>Propofol<br>Benzodiazepines<br>Alcohol<br>Recreational drugs |
| Zuleta-Alarcon (2017) | Literature search on PubMed prior to April 11, 2016. Ovid MEDLINE search 1946-April 11, 2016, Anesthesia care providers. PubMed keywords: anesthesiology, anesthesia personnel, AND substance-related disorders. Ovid keywords: anesthesiology, OR anesthesia, OR nurse anesthetist, OR anesthesia care provider, OR perioperative nursing, AND substance-related disorders | Nonopioid anesthetic drugs<br>Propofol<br>Benzodiazepines<br>Inhalational anesthetics<br>Ketamine |

*ABA*, American Board Association; *DANS*, Disciplinary Action Notification Service; *NDI*, National Death Index; *OR*, operating room.

(Table, Study Characteristics) Modified from Zuleta-Alarcon, A, Coffman JC, Soghomonyan S, et al. Non-opioid anesthetic drug abuse among anesthesia care providers: a narrative view. *Can J Anesth/J Can Anesth*. 2017;64:169–184.

The incidence of death was 28%. Health care providers that abuse propofol tend to be female, have training as an anesthesiologist or nurse anesthetist, and work in the operating room theater.[150] Propofol abuse tends to present early in dramatic fashion such as a motor vehicle accident or other physical injury in the setting of acute intoxication.

Ketamine may make up approximately 2% to 4% of abused substances.[137,139] Ketamine causes hallucinations as well as calming effects.[148,151] The risk of death associated with ketamine may be less than opioids among impaired providers, but the acute impact of delusions, delirium, and confusion have the potential to result in injury. Long-term effects include memory impairment, attention dysfunction, tolerance, and flashbacks.

Inhalational anesthetic drug abuse comprises approximately 2% to 5% of misused substances among anesthesia providers.[137,139,146,148] A 2008 survey demonstrated that 22% of anesthesia training programs had at least one provider who had been impaired by inhalational anesthetics and that 26% of those died.[152] $N_2O$ was the most commonly abused drug, followed by volatile anesthetics. Only 22% of those individuals who abused such anesthetics were ultimately able to return to work. The report noted that only 7% of the anesthesia departments had any pharmacy accounting for inhalational anesthetics.

Anesthesia providers may misuse benzodiazepines to relieve stress and to treat insomnia.[148] Benzodiazepines are the drug of choice for 5% to 15% of anesthesiologists impaired by SUD and are the drug of choice of impaired SRNAs.[137,139,143,145,146] Remifentanil was introduced in 1997 as an opioid with a rapid onset and rapid rate of degradation. Remifentanil does have typical opiate-like effects, but when compared with fentanyl, its significantly shorter duration of activity makes it less likely to be abused than fentanyl. Baylon et al. noted that remifentanil is unlikely to be used "on the street," but if access to the medication and infusion pumps increases and addicts recognize minimal observable effects, abuse of the medication may increase.[153] Remifentanil abuse has been reportedly used by a resident as a foray into opioid abuse.[154]

## ETIOLOGY

The underlying etiology of SUDs among anesthesia providers, who are presumably more intimately aware of the risks, remains undetermined. No study has clearly identified individual factors, and those often cited are not specific to the practice of anesthesiology. Risk factors for SUDs may be biologic, psychological, or occupational.[155]

Hiroi and Agatsuma surmise that certain individuals are more likely to transition from substance use to dependence if they are genetically susceptible based upon animal studies.[156]

A family history of SUDs has also been identified as a risk for relapse among addicted individuals.[157] Individuals receiving medical education within the United States had higher rates than those from other countries.[158]

Personality may play a role in the likelihood of developing SUD. Trinkoff and Storr studied the incidence of SUD among nurses and noted that those in emergency medicine and critical care had higher rates than other nursing specialties.[159] These areas of practice are like those in which anesthesiologists work.

Anesthesiologists directly obtain and administer medications to patients. A review of anesthesiologists treated for SUDs by the Medical Association of Georgia Impaired Physician Program concluded that 85% of residents in the program selected anesthesiology because of access to medications and drugs.[160] Emergency and critical care nurses,[159] and pharmacists also have access to medications and have high rates of SUDs.[161]

Anesthesiologists, like other physicians, often self-medicate rather than seeking appropriate medical care from their physician. Christie and colleagues reported in 1998 that more than 50% of prescription medications used by trainees were self-prescribed.[162] Unpredictable schedules, ease of access to medications, and knowledge of medical conditions were cited as potential causes of this behavior,[162] as may the lack of access to health care providers.[162,163] Fortunately, a study showed that the incidence of self-medication may be decreasing.[164]

## IMPACT

Health care providers who suffer from SUDs generally divert their drugs from the health care facility at which they work. The National Association of Drug Diversion Investigators defines drug diversion as "any criminal act or deviation that removes a prescription drug from its intended path from the manufacturer to the patient. This can include the outright theft of the drugs, or it can take the form of a variety of deceptions such as doctor shopping, forged prescriptions, counterfeit drugs, and internal smuggling."[165]

SUDs in health care providers affect their well-being, their career, and their family. Individuals with SUDs have high rates of divorce and marital discord. The cost of rehabilitation and follow-up care is significant. Problems with medical licensing are common. In addition, the individual with an SUD in a sensitive position may carry the stigmata of impairment. The death rate for anesthesiologists with SUDs is 9% to 15%.[138,139,158]

It is generally believed that the impact of SUD is largely limited to the individual with the disease, but an increasing number of reports of injury to patients is being published. Shaefer and Perz reported on public outbreaks of communicable diseases such as HCV, HBV, and other organisms in hospital settings where health care providers abusing drugs placed patients at risk.[166] These situations arose because of providers diverting drugs from the work environment for their own use.

## PREVENTION AND DETECTION

Prevention of SUDs among health care providers has been largely limited to education on the impact of drug use. These efforts may include presentation of videos demonstrating the death of a promising young resident physician and the impact on his family. Individuals with a history of SUDs are often invited to share their stories of drug use, detection, and recovery. Members of the state Physicians Health Services are often invited to present resources to

**TABLE 88.7** Behaviors and Indicators that Could Indicate Substance Use Disorder

| Potential Indicators at Work | Potential Indicators at Home | Physical |
|---|---|---|
| Changes in behavior (wide mood swings, anger, euphoria, gossip by others) | Withdrawal from family and friends | Pinpoint pupils |
| Progressive increases in narcotic use for anesthetic management | Changes in behavior, mood swings, anger | Diaphoresis, tremors |
| Recurrent documentation errors related to medications | Frequent, unexplained illness | Odor of alcohol on breath |
| Preference for working alone | Risk behaviors—gambling, extramarital affairs | Weight loss |
| Frequent requests for bathroom breaks | Decrease in sexual drive | Wearing of long-sleeved gowns (to hide needle tracks or prevent withdrawal chills) |
| Unusual willingness to provide breaks for others or work additional shifts/calls | Finding of drugs and syringes at home | |
| Frequent appearances in hospital when not on call | Increased use of alcohol | |
| Falling asleep during rounds, in OR | Increase interactions with individuals who use illicit substances | |
| Unexplained absences | | |
| Difficulty contacting when on call | | |
| Excessive postoperative pain in patients | | |
| Direct observation of use | | |
| Sudden death | | |

*OR*, Operating Room

support physicians. Lutsky et al. reported that in 1993, only 15% of anesthesiologists could report receiving any education on impairment during their residency.[167] Booth and colleagues reported that, despite enhanced education over the course of their study, the incidence of SUDs had not decreased.[140]

Detection of SUDs has traditionally relied upon colleagues observing and reporting performance characteristics that could indicate SUDs (Table 88.7). However, many health care professionals will not report or even seek assistance for colleagues who may be impaired. In an investigation of reporting behaviors, only 64% of physicians agreed with the statement, "Physicians should report all instances of significantly impaired or incompetent colleagues to their professional society, hospital, clinic and/or relevant authority."[168] Multiple reasons for not being willing to report were cited, including the perception that it is not one's responsibility to report or a fear of retribution for reporting. Because reliance on observation by colleagues and reporting has proven unreliable and death is too often the initial presenting factor for SUD, institutions are starting to use new measures, including anesthesia record surveillance, vigorous control and testing of returned substances, and drug testing of providers.

Medical record surveillance is the practice of comparing the anesthetic record to the medications that have been dispensed for patient use. Pharmacists or other healthcare personnel manually review the record and compare documentation with the amount of medication returned. Inconsistencies may indicate medication diversion from the patient. Discrepancies in practice patterns may also be detected by record surveillance. Epstein and colleagues retrospectively reviewed medical records through a commercial drug-dispensing system to evaluate discrepancies that could indicate diversion.[169] Factors such as high use of opiates, excessive medication wastage, and late transactions on canceled cases were not indicative of diversion, whereas transactions late in the day after completion of cases and transactions that occurred at locations different from where the procedure occurred were associated with episodes of diversion. These authors posited that a surveillance scheme used in real time might identify episodes of diversion earlier than traditional behavioral observation and reporting methods, an assertion they later validated prospectively.[170]

Most organizations use the practice of witnessed wasting of controlled substances. Such practice involves a second individual observing and documenting that controlled substances remaining after a case are wasted. This system relies upon the integrity of several steps: that the elimination of the entire substance occurs, that both providers are honest, and that the wasted substance is a controlled substance at the appropriate concentration. Leaders at the Mayo Clinic recognized these potential weaknesses and developed a vigorous system to prevent diversion. The system requires that all unused substances are returned to a secure, locked box. The box is returned to the pharmacy, where the amount returned is reconciled with the dispensing record and anesthesia record. Random samples are periodically sent for toxicologic analysis. This process occurs under video surveillance to prevent diversion by the pharmacy department.[141] This system has successfully identified

multiple health care providers and other personnel diverting substances.

Two major events resulted in widespread use of urine drug screening to reduce the incidence of SUDs. During an investigation after an aircraft accident aboard the USS Nimitz in the early 1980s, it was discovered that nearly 50% of the ground crew tested positive for illicit substances.[171] In addition, the passage of the Drug-Free Workplace Act of 1988 required that all federal contractors and all federal grantees establish drug-free workplaces to receive a grant of contract from the U.S. government.[172] The act included the provision that individuals in safety-sensitive professions could be subject to drug testing. The Department of Anesthesia, Critical Care, and Pain Medicine of the Massachusetts General Hospital (MGH) first reported the feasibility of drug testing in anesthesiologists 2008.[173] The incidence of SUDs prior to implementation of testing was 1% among all residents and 2.2% among first-year residents. There were no cases of SUDs reported within the first 4 years of implementation of the program, although the results were not statistically significant. In 2010 Tetzlaff and associates reported their experience developing an SUD prevention program at the Cleveland Clinic's Anesthesiology Institute.[174] The clinic implemented a comprehensive substance abuse prevention protocol that included randomized urine toxicology screening and "for cause" testing that would be initiated in the event of a significant decline in performance. Assessment of the prevention program is ongoing.

Implementation of a drug-testing program is not without challenges and concerns. Senior physicians may opine that their years without a problem indicate that they are without risk and should not be subject to an invasive test without cause. Although Alexander and colleagues reported that the highest rate of SUDs among anesthesiologists occurred within the first 5 years after medical school, the risk is never eliminated and extends into the senior years of one's career.[175] Some argue that if drug testing is not a condition on a contract than it cannot be required. Initially, participation in the MGH drug-testing program was voluntary, but testing became mandatory for all physician members in 2005.

False-positive results are a legitimate concern for those tested, as well as for those administering the program. For example, one of two false-positive tests at MGH was likely due to the consumption of the poppy seeds in a bagel eaten the morning of testing. It was found that the testing threshold for morphine (300 ng/dL) was set far lower than the federal level of 2000 ng/dL.[176] In the second event, the initial enzyme-linked immunosorbent assay reported the presence of ketamine, whereas confirmatory gas chromatography/mass spectroscopy reported a result that was indeterminant. Policy dictates that a second sample is collected at the original test. This second sample was sent to another certified laboratory where a "negative" result was found.[176] Some test results may be positive due to legitimate medication use for which an individual has a valid prescription. A certified, unbiased Medical Review Officer trained to the standards of the Department of Health and Human Services Substance Abuse and Mental Health Services Administration Center for Substance Abuse Prevention should review all results.[177]

## INTERVENTION, TREATMENT, PROGNOSIS, AND REENTRY

SUDs curtail promising careers and claim the lives of anesthesiologists every year.[175] Studies have shown that death is the initial presentation in 9% to 16% of cases.[138,139,178] Residents who have an SUD during their training have a markedly increased risk of death after training compared with their colleagues without an SUD.[141]

When an SUD is identified or suspected, it is critical that concerned and compassionate colleagues intervene to prevent injury or harm to patients and to help the impaired individual. An organized, structured, and supportive plan to present the concerns to the impaired individual is critical. Such an "intervention" is more likely to maintain the confidence of the individual than a "confrontation" where the individual feels that guilt is presumed.[179] A suggested approach used at MGH is that a consistent team including the director of the SUD prevention program, another department leader, and a designated psychiatrist familiar with SUDs and the department's policy should be involved in all interventions. Other individuals such as a mentor or certified registered nurse anesthetist (CRNA) leader may be included when appropriate. The intervention team discusses each case before meeting with the individual. The individual is removed from clinical duty in a confidential manner. The issues of concern are presented in a supportive and nonconfrontational manner. If additional drug testing is indicated, the individual is escorted for testing. In the case of admitted or demonstrated SUD, treatment is required. Should an individual refuse to seek care, an immediate report to the Board of Registration in Medicine is made. When it is uncertain whether an SUD is the cause of impaired performance, a medical leave of absence is granted pending completion of evaluation and testing. In either circumstance, access to controlled substances and the operating room is restricted, pending outcome of an investigation.

It is critical that factors other than SUDs be considered, because the "impaired" anesthesiologist is not necessarily an "addicted" anesthesiologist.[180] Other issues that may lead to inadequate or unsafe performance may be depression, anxiety, financial difficulties, and family struggles, and other medical illness may manifest in similar ways to SUDs. Treatment and recovery after a diagnosis of an SUD is complicated for professionals whose livelihood involves daily exposure to the substances which they misuse. In a report by the California Physicians Diversion Program,[181] anesthesiologists made up 5% of the physicians in California yet 17.4% of those in the program. The recovery rate was 69%, with the majority reentering anesthesiology (96%). The relapse rate among those using opioids was 16%. Paris and Canavan studied anesthesiologists compared with physicians from other specialties.[182] The relapse rate was high (40.6%) but like other specialties, relapse was less likely when the individual entered another specialty. In a 5-year longitudinal study of physicians enrolled in physician health programs (PHPs) between 1995 and 2001, a subset of 102 anesthesiologists of the 904 physicians was independently analyzed.[183] Anesthesiologists primarily enrolled in the recovery programs due to opioid abuse, whereas alcohol was the most common drug of abuse for other physicians. Compared with other physicians, anesthesiologists had

no higher rate of mortality, relapse, or disciplinary action during the period of recovery. The study's conclusions are limited because only 16 of the 48 PHPs elected to participate because of lack of resources or regulatory impediments to participation. Factors associated with increased risk of relapse specifically among physicians have not been studied well. Domino and colleagues reviewed risk factors for physicians in the Washington Physicians Health Program in 2005.[157] Among a cohort of 292 health professionals enrolled in the program, 74 had at least one relapse (25%). Those with a family history of SUD, as well as individuals whose drug of misuse was a major opioid and who had a coexisting psychiatric disorder, had higher risks of relapse. Individuals with all three risk factors—family history, a coexisting psychiatric illness, and abuse of a major opioid—had the highest relapse risk.

States, hospitals, and departments often rely on the help of PHPs to guide the recovery of physicians impaired by any condition, particularly SUDs. PHPs are not addiction programs, but they do provide active case management and guidance through the diagnosis, treatment, recovery, and reentry process. Individuals with SUDs are required to sign contracts with a PHP and agree to treatment (usually inpatient), follow-up, monitoring, and other stipulations during recovery. PHPs offer a temporary safe haven during the initial phases of management. PHPs work closely with state medical boards to ensure that a physician is compliant with requirements of a comprehensive recovery process.[184]

Specialists in the treatment of physicians with SUDs have identified six lessons that appear to promote long-term recovery through PHPs[185]: (1) Successful programs promote a zero-tolerance policy for any use of alcohol or other nonmedical drugs. (2) Evaluation of individuals should be complete, comprehensive, and patient-focused rather than merely repeating the same practices for every single patient. (3) Frequent random drug testing for both alcohol and drugs serves as a constant reminder of the obligation of the individual being treated. (4) PHPs use leverage with medical boards, hospitals, and medical groups, which may serve as a deterrent to relapse. (5) PHPs define what constitutes a relapse and act in a quick and certain way with meaningful consequences. (6) Lastly, those in recovery working through PHPs generally must be involved in 12-step programs such as Alcoholics Anonymous or Narcotics Anonymous.

The use of naltrexone may reduce the chance of relapse among anesthesiologists in recovery. The state of Florida mandates that anesthesiologists referred for opiate disorders are contractually required to use naltrexone for 2 years.[186] Naltrexone has side effects such as headache, fatigue, insomnia, anxiety, and nervousness, all conditions that can impair performance. In a small prospective study, 11 anesthesiologists treated with naltrexone were compared with 11 controls: only one individual in the naltrexone program relapsed while 8 of 11 (72%) in the untreated group relapsed. Those on naltrexone also had higher rates of return to the practice of anesthesiology.

Whether SUD residents in anesthesia are returned to their training programs or are retrained in either a different specialty or another career is even more controversial. In a review of outcomes for residents treated for chemical dependency, most program directors (80%) had at least one impaired trainee and 19% reported a pretreatment fatality.[187] A high percentage (92%) of trainees attempted reentry into anesthesiology, but only 46% ultimately completed training. The rate of death was 9%. A survey of anesthesiology residency training programs in 2007 showed that nearly two thirds of program directors had at least one resident who required treatment for SUDs.[188] The relapse rate after treatment was 29%, and death occurred in 10%. Despite these statistics, 43% believed that residents should be allowed to continue their training. Bryson and Levine conducted an intensive 12-month posttreatment program involving an anesthesia simulator followed by gradual reintroduction to the clinical practice of anesthesia.[189] Five residents participated in the program, and three (60%) successfully finished their training program. Two of those individuals remained in recovery at 3 and 6 years, whereas one relapsed at 9 years.

The decision whether to return or retrain is difficult, and circumstances vary on an individual basis. Residents often do not have the social and financial supports of graduated physicians, and they are exposed to the substances of risk for perhaps 40 more years. In addition, their youth may predispose them to denial of the disease.

SUDs among anesthesiologists remain a problem. Enhanced education and substance control measures should continue. Other efforts such as drug testing should be explored. When an individual is suspected or found to have an SUD, a timely, compassionate, and professional intervention is necessary to ensure the safety of the individual and patients.

## Fatigue

Excessive tiredness due to inadequate sleep, physical illness, or other causes can result in fatigue. In general, physicians are not able to compensate for loss of sleep or to recover from illnesses because of the requirements of their work environment to patient care issues or work structures. Fatigue may place patients at risk of injury, as well as impact the health and safety of anesthesiologists. Fatigue in trainees became a public concern with a case involving Libby Zion, a young woman whose unfortunate death was determined in court to be related to 36-hour duty periods worked by the physicians providing her care. Physicians should understand the causes of fatigue, the impact on patients and themselves, and the means to manage the challenges ever present in a difficult and unpredictable work environment.

### INCIDENCE AND IMPACT

Few studies of the impact of fatigue have been performed in the population of providers involved in anesthesia care. Gravenstein and colleagues conducted a survey of anesthesiologists, residents, and CRNAs wherein residents and CRNAs noted that they occasionally worked beyond what they would consider their limitations and that they had made errors associated with fatigue.[190] Ten years later, Cao and colleagues evaluated the differences in performance during day and night shifts among residents. Residents had a more negative mood at night, although workload ratings and alarm response times were no different between the two

**TABLE 88.8** Accreditation Council for Graduate Medical Education Duty Hour Rules and Modifications

| 2003 ACGME Duty Hour Standards | 2017 ACGME Clinical Experience and Education Modifications |
|---|---|
| 80-h weekly limit (averaged over 4 weeks) | Clinical work done from home must be counted toward the 80-h weekly maximum |
| 10 h between work shifts (suggested) | All residents must have at least 14 h free of clinical work after 24 h of clinical assignments |
| Limit of 24 h of continuous duty plus 6 for transition of care | Clinical work for all residents must not exceed 24 h of continuous schedule clinical assignments |
| One day in 7 free from all obligations | |
| In-house call no more than every 3 nights | |
| Options for some programs to request 8 h additional time | Clinical work exceptions may be granted by the RRC up to a maximum of 88 h based on sound educational rationale |
| | Residents who have handed off work have the flexibility to remain at work in unusual circumstances for the benefit of patient care. Hours must count towards the 80-h work week |

*ACGME*, Accreditation Council for Graduate Medical Education; *RRC*, Residency Review Committee.

shifts.[191] More recently, Husby and colleagues studied the impact of short- and intermediate-duration hospital calls on anesthesiologists.[192] Reaction times were significantly worse after 18-hour shifts, but not after shorter shifts. The incidence of adverse events has been found to be higher later in the day; the lowest rate of adverse events was found at 9:00 AM, whereas the highest rate was at 4:00 PM.[193]

The impact of fatigue on the safety of the physicians themselves may be significant. Extended work duration of interns is associated with increases in percutaneous injuries.[194] A lapse in concentration and fatigue were the most commonly cited contributing factors. Injury was more common during the night shift than during the day. Depression, fatigue, and sleepiness were associated with a higher likelihood of a motor vehicle incident in resident physicians.[195] The personal lives and well-being of trainees may also be impacted by sleep loss and fatigue. A study of 149 resident-physicians at five academic medical centers revealed that many residents perceived that sleep loss and fatigue had a major impact on their personal lives such that personal and social activities were deferred or postponed.[196]

Attempts to restrict duty hours have been implemented by the ACGME. The benefit of limitation of duty hours is unclear, and negative consequences on patient care and education may result. Early studies of the impact of duty hour restrictions demonstrated that when efforts were made to reduce sleep deprivation, medical errors were lower, as were patient hospital length of stay and laboratory tests ordered,[197] but this has not been a consistent finding, and the relationship between duty hour restrictions and quality of care remains controversial.[198]

## GUIDELINES

Training for resident physicians requires a balance between the safety of both patients and residents, as well as assurance that optimal educational outcomes are achieved. The ACGME implemented duty hour restrictions for trainees in 2003 and updated these restrictions in 2011. At their core, the restrictions included an 80-hour weekly duty limit, 10 hours of rest between shifts, and no more than 24 hours of continuous duty with a limit of 6 hours for transition of care and education.[199] Many potential benefits were anticipated including improvements in patient care, improved resident quality of life and health, and decreased risk of personal harm due to fatigue.[200] At the time of implementation of duty hour restrictions, many physicians anticipated several unintended consequences, including discontinuity of care, an increased work burden on attending physicians, negative impact on professionalism and the perceptions of the profession, poor preparation for the realities of independent practice, a reduction in educational opportunities, and a major economic impact (Table 88.8).

Multiple studies have been performed on the impact of these changes. Ahmed and associates performed a systematic review of the effects of duty hour restrictions in surgery.[201] There was no significant improvement in patient safety. Their review found that wellness improved, and fatigue and burnout declined after implementation of the 2003 guidelines but further improvements were not seen after the 2011 modifications. The effects on education and training were either a worsening or no change. Written examination scores were unchanged, but passage of oral examinations decreased in surgery.

## REQUIREMENTS AND RECOMMENDATIONS

The ACGME Program Requirements for Graduate Medical Education in Anesthesiology require inclusion of formal efforts to educate faculty and residents in the recognition of fatigue, alertness management, and fatigue mitigation. Programs are also required to ensure adequate sleep facilities and safe transportation options after duty.[202] The Association of Professional Sleep Societies' Committee on Catastrophes, Sleep, and Public Policy developed a consensus report concluding that human performance is at its most vulnerable period between 1:00 AM and 8:00 AM, with a less pronounced period from 2:00 PM to 6:00 PM (Table 88.9).[203] It is also known that sleep duration less than 7 hours affects cognitive performance involving vigilance, attention, cognitive processing speed, and working memory, and at least 7 to 8 hours are recommended per night.[204] Less sleep and patterns associated with chronic sleep deprivation are associated with even more impairment. Recommendations are in Table 88.9.

Researchers at the Mayo Clinic studied whether capping residents' patient census would improve the perception of workload among residents.[205] These changes led to improvements in ratings of workload appropriateness and conference attendance. Duty hour violations were

**TABLE 88.9** Recommendations of the Association of Professional Sleep Societies

| Observation | Recommendation |
|---|---|
| The time of 1 AM-8 AM constitutes a time span when human medical and performance catastrophes are far more likely to occur<br>A second but less pronounced period from 2 PM to 6 PM constitutes a second period of vulnerability | Increased awareness is necessary. Policymakers are urged to consider relevant aspects of sleep physiology that affect performance. |
| Inadequate sleep, even as little as 1-2 h, can greatly exaggerate the tendency for error during the time zones of vulnerability | Programs should be developed to identify the signs of sleep-related error in vehicle operation and on the job, particularly in industries that have a responsibility to minimize accidents and effort for the sake of public health and safety |
| | Industries and services impacting public safety should address the physiologic needs of workers |
| | Attention should be given to identification of the least adaptive shiftwork schedules and to the implementation of schedules that promote health and safety |

Modified from Mitler MM, Carskadon MA, Czeisler CA, et al. Catastrophes, sleep, and public policy: consensus report. *Sleep*. 1988;11:100–109.

decreased, as were patient readmissions, but other safety outcomes, such as the rate of rapid response team and "code blue" events, were unchanged.

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**Complete references available online at expertconsult.com.**

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