



Occupational Risks for Anaesthesiologists and Precautions

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Abstract

Anaesthesiology is an extremely stressful and risky branch of medicine. New techniques, new procedures, and innovations in anaesthesia increase the responsibilities and obligations of anaesthesiologists day by day. Operating rooms and intensive care units, which are the working environment of anaesthesiologists, are considered to be an unhealthy workplace. Anaesthesiologists are exposed to various potential physical, chemical, biological, ergonomic, and psychosocial risk factors and hazards in their work environments. The occupational risks anaesthesiologists are exposed to threaten their health and may cause their professional performance to decline. This article aimed to raise awareness about the occupational risks, hazards, and precautions in anaesthesiology practice.

Keywords: Anaesthesiologists, anaesthesiology, occupational, occupational health, occupational safety, risk

Introduction

Basic approaches to occupational health and safety include risk assessment, workers' health surveillance, and work environment monitoring (1). Workers' health surveillance should start with medical examination for employment, which should be repeated intermittently according to the characteristics of the occupational process. Risk assessment reports should be prepared at the workplace, it should be performed continuously, and the information on the reports should be revised if there are new developments related to the risk. According to the risk assessment report, current risks should be monitored, intermittent measurements/evaluations should be made, and workers' awareness should be raised regarding the new risks in the work environment. The programs for risk prevention and promotion of workers' health include identifying risk factors, continuous monitoring of the working environment in terms of existing risks and possible new risks, developing special protection and control applications for risks, raising awareness, occupational health and safety training, and continuous and planned monitoring of workers' health (1, 2).

Occupational risks for anaesthesiologists can be classified in different ways (3, 4). For example, the Brazilian Society of Anaesthesiology and the World Federation Societies of Anaesthesiologists divided the risks into 5 principal categories:

1. Physical factors and safety, such as ionizing and non-ionizing radiation, noise and vibration, heat, ventilation, lighting, electrical appliances, fires, and compressed gases
2. Chemical factors, such as latex allergy and exposure to anaesthetic gases
3. Biological factors, such as viruses, bacteria, and fungi
4. Anaesthesia practices, such as chronic occupational stress, psychosocial disorders, and drug addiction
5. Ergonomic risks and labour standards, such as work organization, work model, workload, intense responsibility, and violence.

In this article, in contrast with the study mentioned earlier, occupational risks will be evaluated under the following categories: 1) physical factors, such as lighting, noise, heat, radiation, and electromagnetic fields (EMFs); 2) chemical factors,

such as anaesthetic gases, pharmaceutical substances, sterilizing agents, and latex; 3) biological factors, such as respiratory viruses, herpes viruses, rubella, rubeola, influenza types A, B, and C viruses; coronavirus; severe acute respiratory syndrome (SARS)-associated coronavirus; norovirus; *Clostridium difficile*; Epstein-Barr virus; viral hepatitis; human immunodeficiency virus; Cruetzfeldt-Jacob disease; tuberculosis (Tbc); and surgical smoke viruses; 4) ergonomic factors, such as inappropriate working positions, challenging movements, inappropriate equipment, complex work environments, and sharp objects; and 5) psychosocial factors, such as shift work, night calls, stress, violence, human relationships, substance abuse, suicide, and exhaustion.

Physical Factors

Noise

In the operating room where the anaesthesiologists work, noise levels may rise up to 75–90 dB, almost reaching the noise levels on a highway. Sporadic sounds can reach up to 100–120 dB. Psychological productivity is negatively affected by noise. Excessive noise levels disturb the anaesthetist's mental productivity, short-term memory, and multitasking skills and cause behavioural changes and sleep disorders (3, 4). Noise affects the endocrine and neurological systems. Chronic exposure to noise increases the catecholamine, cholesterol, triglyceride, and free fatty acid levels. Noise also affects the ability to hear important verbal communication and information about various equipments. Noise causes stress, increased irritability, and hypertension. Excessive noise also causes hearing loss. Anaesthesiologists suffer up to 50% hearing loss because of chronic acoustic trauma (4). According to a 2013 anaesthesia risk assessment report (ARAR), 88% of anaesthesiologists stated that there was excessive noise in the work environment (5).

Heat

Operating room environments are very influential on working conditions in terms of heat. Working in below- or above-normal heat levels reduces work performance and productivity (6).

Main Points:

- Anaesthesiologists are exposed to numerous potential occupational risks.
- Occupational hazards are classified as physical, chemical, biological, ergonomic and psychosocial factors.
- Raising awareness about occupational risks
- Providing a safe working environment
- Preventive measures
- Prioritizing the safety and satisfaction of employees and
- Structured national occupational safety laws required for occupational safety in anaesthesiology will contribute to increase occupational health and safety.

Lighting

Operating rooms are usually located in closed and dark environments. Working in an environment without sunlight causes vitamin D deficiency and related health problems (7). Visual disorders and occupational accidents can occur more frequently in the operating rooms with low lighting levels and artificial lighting (8). According to the 2013 ARAR, 46.5% of anaesthesiologists stated that there was insufficient lighting (5).

Electromagnetic fields

Exposure to EMFs owing to the extensive use of a large number of electrical appliances has a trigger effect on several types of cancer and increases stress. EMFs increase the risk for brain and breast cancer and leukaemia. EMF exposure also causes headaches, blurred vision, feelings of discomfort in the eye (itching, tearing, and stinging), hearing deficiency, exhaustion, and fatigue (1, 3).

Radiation

Radiation, which is an important physical risk, should be investigated in 2 groups, ionized and non-ionized radiations, which have different sources and effects.

Exposure to ionizing radiation during imaging procedures, especially C-arm fluoroscopy, is a major problem, and there is also exposure to ionizing radiation during endoscopic retrograde cholangiopancreatography, specific anaesthesia applications (thoracic endovascular aortic repair, endovascular aneurysm repair) in cardiac catheterization laboratories, and neurointerventional angiographic procedures (3, 9). Being close to an imaging device increases this risk. The anaesthesiologist is exposed to 6 times more radiation than other personnel during the neurointerventional angiographic procedures (3). The effects of radiation exposure vary depending on the specific organ of exposure, age, and sex. Radiation leads to cell death and organ failure. It causes malignancies and damage to chromosomes and cells (4). The recommended dose limit of annual radiation exposure is calculated to be less than 15 mSv/year (10). The Occupational and Safety Health Administration has specified the potential ionizing radiation exposure as 5 Rem and $(N-18) \times 5 \text{ Rem}$ ($N=\text{age}/\text{year}$) in a lifetime (4). In the past, ionizing radiation was not considered to be an important problem for anaesthesiologists, but recently, there is a growing risk for anaesthesiologists working in operating rooms as well as in other areas (such as cardiac catheterization laboratories). Although all the necessary protective measures are taken during radiation exposure, a distance of at least 90 cm from the primary source is required to reduce the risk (3, 4). Because wearing protective equipment is important, there should be enough protective equipment for the entire team in the work area where the exposure occurs, and the protective equipment should not be torn or broken. Ionizing radiation exposure causes an increase in the

incidences of leukaemia, thyroid cancer, cataracts, germ-cell damage, and malformation. The International Commission on Radiological Protection has stated that the maximum exposure dose is 100 mRem/week and 5 Rem/year. Fluoroscopy performed with minimally invasive interventions could cause serious problems. Anaesthesiologists have high risks of radiation influence because they work close to the source. There are no sanctions for monitoring anaesthetists' radiation exposure in the current guidelines despite serious radiation exposure; moreover, there is no follow-up or monitoring in health institutions regarding dosimeter usage for anaesthesiologists, and dosimeter requests are not fulfilled. In addition, health institutions and organizations do not take the necessary measures and precautions in terms of permission to be exposed to radiation and provision of necessary protection, and radiotherapy leave applications are not provided to anaesthesiologists as a right despite the fact that they work in a dangerous area.

Laser applications cause non-ionizing radiation exposure. Most of the lasers used in the operating rooms are class-IV devices, which are dangerous to the eye. The distance from the laser source does not reduce its effects. The skin and eyes are particularly at risk owing to laser applications (3). Non-ionizing radiation causes corneal and retinal burns, macular damage, optic nerve damage, and cataract formation (9). Protective goggles should be worn. Surgical smoke that emerges during the laser operation contains carcinogenic substances. Inhaling infectious particles and viral DNA, which can occur in laser applications, negatively affects health. Moreover, contact with O₂ and N₂O during laser surgery can be a fire hazard.

Protection from radiation includes preventing the unnecessary use of imaging procedures, implementing the specific occupational health and safety practices, presence of only the patient during the procedure, using personal protective equipment, keeping a sufficient distance from the source, using personal dosimeters in the operating rooms and by intensive care workers, using materials with lower reflective properties (that is, dark or black materials) in areas where lasers are used, avoiding flammable anaesthetics, keeping the O₂ concentration below 25%, using non-inflammable endotracheal tubes (special materials or aluminium coating), intermittently assessing relevant health problems, and not compromising legal limits (3).

Chemical Factors

Exposure to chemical factors can occur via dust, smoke, mist, gas, vapour, or direct contact. The respiratory system, gastrointestinal system, and exposed skin are at risk, and agent concentration, respiratory index, agent toxicity, individual susceptibility, and duration of exposure are important. All

these factors may have a combined effect and cause damage. The leading chemical factor is anaesthetic waste gases (4).

The main problem is the inadequate anaesthetic waste gas disposal system. Although the maximum amount of anaesthetic gases that may be present in the operating room is known, virtually no operating room is measured for waste anaesthetic gases. The operating room can get contaminated by several factors, such as connection errors of the current control valves, inappropriate masks, uncuffed tracheal tubes, paediatric respiratory circuits, side stream gas analysers, clogging of the hospital waste gas system, and leakages in low-pressure circuits (CO₂ adsorbent, sealing rings, hose, and so on). Long-term exposure to low-dose anaesthetic gases, both the anaesthetic agent itself and its metabolites and by-products, risks the health of anaesthesiologists. Chronic exposure may cause headaches, nausea, drowsiness, fatigue, difficulties with judgment and coordination, and irritability (11, 12). Exposure to anaesthetic agents causes oxidative stress. The possible effects after exposure to anaesthetic gases could be organ toxicity, hepatotoxicity, nephrotoxicity, genotoxicity, pulmonary toxicity, chromosome aberrations, micronuclei formation, sister chromatid exchange, and carcinogenesis. Although no change in incidence was reported for anaesthesiologists in terms of carcinogenesis, risk has been detected in animal experiments. In addition, an increase in spontaneous miscarriages and congenital anomalies owing to the effects on the reproductive system was present. The teratogenic effect of N₂O has been experimentally proven. Moreover, exposure to anaesthetic gases causes psychophysiological effects and distortions in the cognitive and motor functions (13). In the 2013 ARAR, 82% of anaesthesiologists reported that they smelled gas in the work environment and 75.5% stated that ventilation was not sufficient (5). Maximum concentrations of anaesthetic gases in various countries during an 8-hour workday are given in Table 1.

When the agents are solely inhaled at the concentrations indicated in the table, although these are the maximum allowable concentrations in the ambient air, the maximum permissible values are reduced to 0.5 ppm when halogenated agents are combined with N₂O (11, 14).

Latex allergy is also a common problem in operating rooms. Latex exposure can cause irritating contact dermatitis, delayed type IV reactions, and anaphylactic shock. Contact urticaria, rhinitis, conjunctivitis, and asthma may also occur (11). Latex-free gloves and materials should be used for protection, and hands should be washed after contact (3).

Biological Factors

Anaesthesia workers are exposed to a growing number of infections in the work environment. This is because the number

Country	N ₂ O	Halothane	Enflurane	Isoflurane	Sevoflurane	Desflurane
USA/NIOSH	25	2	2	2	2	2
USA/ACGIH	50	75				
Austria		5				
Denmark	100	5	2			
France		2				
Germany	100	5	20			
United Kingdom	100	10	50	50		
Italy	100					
Norway	100	5	2	2		
Sweden	100	5	10	10		
Switzerland	100	5	10	10		

USA/NIOSH: United States of America/The National Institute for Occupational Safety and Health; USA/ACGIH: United States of America/American Conference of Governmental Industrial Hygienists

of antimicrobial-resistant bacteria is increasing, along with an increase in the number of immune-deficient patients and more frequent encounters in operating rooms. In addition, various diseases that were not previously known to be viral are also now known to be so, and these viral diseases cause problems over a long term. Pathogens of a special concern for anaesthesiologists are as follows: influenza species A, B, and C; human respiratory syncytial virus; SARS-related coronavirus; norovirus; *Clostridium difficile*, herpes simplex viruses; Epstein-Barr virus; rubella; rubeola; hepatitis A, B, and C viruses; human immunodeficiency virus; methicillin-resistant *Staphylococcus aureus*; swine flu; and Tbc (4, 11). Percutaneous transmission causes hepatitis B in 40% of cases and is very infectious (11, 15). Reassessment is necessary every 5 years to assess the immunity. If infected with hepatitis B virus, 3 series of hepatitis B vaccines should be administered with immunoglobulin (16). After an occupational exposure to hepatitis C virus, transmission risk was estimated in 2% of the cases (11). Tbc may be transmitted during bronchoscopy, laryngoscopy, tracheal intubation, aspiration, and mechanical ventilation. There should be very little contact with patients with Tbc. If necessary, a tuberculin test should be performed, and chemoprophylaxis should be applied. Using appropriate protective clothing and personal respirators, limiting the number of personnel in contact with the patient, and delaying surgery until the patient is non-infectious are strategies to prevent disease transmission (11). During the use of cryogenics, helium spreads into the environment, which can cause hypoxic conditions. Vapour produced during diathermy may pass through surgical masks because surgical masks cannot prevent the passage of particles as small as 0.5 µm. The particles in the smoke have a diameter of 0.31 µm. Although suction systems are used to prevent smoke emissions, diathermy smoke can also cause harm with various chemicals. This smoke can contain toluene, styrene, and carbon disulphide. Moreover, DNA

of the human papillomavirus and other viruses diffused in the environment can be inhaled depending on the process (11, 15, 16).

Biological factors are encountered during medical intervention and also owing to sharp-object injuries. Damaged skin and eyes are especially vulnerable to biological factors. Anaesthesiologists most often inject needles into their own hands when suturing the central venous catheters or closing the needle tip. Transmissions also frequently occur via bodily fluids other than blood. Transmissions can occur through amniotic, cerebrospinal, pericardial, pleural, and synovial fluids; immobilized tissues and organs; exudative burns or skin lesions via fluid; vaginal secretions; and semen (3). A clean working environment should be provided for combating the biological agents (for example, appropriate disposal of sharp objects in garbage bins), risk-free behaviour must be known and implemented, personal protective equipment (gowns, masks, eye protection, gloves, shoe covers, and so on) should be provided and used, routine control programs should be developed, and post-transmission intervention programmes should be implemented. Vaccination of seronegative healthcare workers should be considered (11).

Ergonomic Factors

Anaesthesiologists frequently encounter situations that cause inadequate posture, monotony, repetition, shift work, and stress during the daily routine. According to the 2013 ARAR, 85% of anaesthesiologists reported that they had ergonomic inconveniences (5). The height of the anaesthesia machine, operating table, and monitors should be adjusted according to the height of the anaesthesiologist. Inappropriate working positions, challenging movements, working with inappropriate tools, complicated working environments, and using sharp objects can cause musculoskeletal system disorders (tendon

and fibre damage, spinal cord injury, spinal diseases, lumbar herniation, muscle contractions, and so on) and job accidents (crashes, falling, injuries, getting hit by an object, and so on) (17). Problems in metacarpopharyngeal joints owing to holding the mask and lacerations in fingers when breaking ampules may be frequent. Plastic-hinged ampules should be preferred. It is required to provide airway safety with laryngeal mask airway instead of applying a face mask for a long time (3, 17).

Working with ergonomically suitable equipment, creating appropriate and sufficient physical space, and providing equipment–environment compatibility along with employee training factors may prevent the ergonomic problems.

Psychosocial Factors

Organization of work in terms of psychosocial factors is the main determinant and the primary preventive measure. The daily/weekly workload, taking a lot of responsibilities, shift work, night calls, different and extensive working areas, use of personal rights, and wage policies cause stress, which causes deteriorations in social relations, decreases in job satisfaction, isolation, exhaustion/burnout syndrome, substance and drug use, and suicidal thoughts and tendencies (4, 18). According to the 2013 ARAR, 45% of anaesthesiologists work 50 hours per week, 62% of those are exposed to mobbing, environments for 60% lack occupational health and safety measures, 41% of anaesthesiologists cannot use legal leave, 90.5% of anaesthesiologists do not take breaks between regular lunch breaks and rest, and 86% are incapable of making manage-

rial decisions (5). Chronic occupational stress disrupts mental and physical health and causes occupational accidents and injuries. Extreme chronic stress is harmful; it can contribute to mood issues and result in sleep disorders and gastrointestinal, musculoskeletal, and cardiovascular diseases. Stress-related outcomes also result in physical injury, disability, decreased productivity, and increased disability at work (12). Moreover, unpredictability of the profession, obligation to stay awake for long time periods, production pressures, medico-legal cases, difficulties in relationships with people, economic uncertainty, and interpersonal conflicts can cause serious problems. Catastrophic or unfavourable patient results and possible complications following procedures cause stress. In a recent survey, 84% of anaesthetists admitted to being part of a serious or fatal situation and more than 70% said that they had experienced guilt, anxiety, or a sense of personal responsibility. It is also stated that the alcohol addiction rate for anaesthesiologists is 28%. In addition, anaesthetics, such as propofol, ketamine, thiopental, lidocaine, N₂O, and other volatile agents are also addictive. Psychiatric support should be received for dealing with psychosocial factors. Communication and teamwork should be improved (19).

Insomnia and fatigue, in particular, have caused multiple major occupational accidents, including the Chernobyl disaster and the Space Shuttle Challenger disaster. Fatigue also damages the performance of anaesthesiologists. Fatigue can cause mood issues, lack of wakefulness, memory problems, short-term deterioration in cognition, prolonged reaction time, disruption and reduction of the decision-making process during the clinical decision-making phase, distracted attention, and reduced performance. All these factors threaten patient safety as well. Long working hours are also an important problem. Stress is an inevitable factor in anaesthesiologists' professional and personal lives that can lead to both mental and physical adverse health effects (4).

Occupational health and safety applications for work organizations need to include a business plan prepared with the participation of employees, clear determination of work and rest periods, clear and precise determination of duties, equitable workload distribution, and employee participation in business plan renewals. In addition, employee awareness of these issues will enable their colleagues to notice the problems as soon as they occur. Employees should be regularly monitored for psychosocial influences, counselling and support systems should be established, and resting places reserved for anaesthesiologists should be provided; these areas should be independent, limited in access, and noise-free and should offer spaces to lie down (Table 2) (20).

In anaesthesiologists, job characteristics, job complexity, stressful working environment, difficulty in controlling the

Table 2. World Federation of Societies of Anaesthesiologists-2014 Working Organization Requirements

Anaesthesiologists should not work over 48–50 hours per week.
There should not be more than 5–6 consecutive hours of work without small breaks.
Daily work must not exceed 10 hours.
In a week, there should be no more than two 12-hour night shifts.
Work and family life balance must be provided.
There must be rest days.
There should not be continuous work over 2 shifts.
There must be at least 10 hours between 2 shifts.
There should be at least 1 rest day after 24 hours of work.
There should be at least 1/2 hour of rest in an 8-hour shift.
There should be at least two 1/2-hour rest periods in a 12-hour shift and enough time to eat.
There should not be a night shift for people over the age of 55 years.
There should be a 15-day vacation for every 4-month work period.

routine, possibility of legal problems, professional expectations, and job insecurity cause occupational stress. This can lead to work–life imbalances, disturbances in relationships with their children, marriage difficulties, lack of emotional support, divorce, and broken families (21). Stress can cause a decrease in interest in the work, absenteeism, dissatisfaction, low-quality work, malpractice risks, disruption in career plans, and early retirement. Physical (chronic fatigue, gastroduodenal ulcer, gastritis, hypertension, arrhythmia, angina, musculoskeletal disorders, neurological diseases, low immunity, reproductive system diseases, and spontaneous miscarriage risks), physiological (emotional disorders, such as anxiety, distress, and depression, and risk of suicide), behavioural (alcohol, substance and drug use, and aggressive behaviour), and intellectual (concentration impairment, attention deficit, and decreased work performance) problems may occur because of occupational stress (2, 22).

Excessive workloads, injustice, lack of professional recognition, conflicts in principles and with team members, loss of control over excessive responsibilities, excessive bureaucracy, and institutional and environmental features can cause burnout syndrome (23). Unfortunately, many of the features of healthcare providers, such as idealism, perfectionism, and a high sense of responsibility, can make them more vulnerable to feelings of inadequacy if the high standards are not met. Common causes of burnout syndrome among anaesthesiologists are production pressure, over-regulation, long work hours, failure to keep plans under control, decreases in repayments, rapidly developing medical knowledge base, and difficulty balancing personal and professional lives (24). Physicians suffering from burnout are predisposed to medical errors and malpractice cases. Burnout also contributes to a variety of diseases, including cardiovascular disease, and substance abuse. Significant degrees of burnout syndrome have been detected in more than 50% of the anaesthesiologists who have academic careers (25). Anaesthesiologists generally work independently and may feel that they have less control over their professional lives than their colleagues in other specialties; loneliness can also contribute to conflicts in an individual's personal life.

Typical stress reportedly increases in people with 7–10 years of work experience, long working hours, night shifts, work dedication, and the role of responsibility (being responsible for the 51% departmental increase in the incidence of burnout syndrome) (20, 26). Stress management strategies should be developed and implemented (maintaining good discipline in daily schedules; communicating and discussing problems with colleagues, friends, or spouses; having hobbies; relaxing; maintaining a good sleep schedule; regularly exercising; and good nutrition) (3, 25).

Owing to the nature of anaesthesiology, sometimes errors that can occur will result in disaster, causing medico-legal cases to be filed. This situation could be a potential risk factor for anaesthesiologists. Non-professional pressures (for example, financial and civil) should be taken into account in understanding drug addiction and dependence.

Burnout syndrome manifests as physical (fatigue, sleep disorders, headaches, impotence, and digestion system diseases), psychological (restlessness, anxiety, depression, and hopelessness), behavioural (aggressiveness, defensive behaviour, and drug use), and occupational symptoms (absenteeism, low performance, and decreased interest in work).

Although stress control training at a personal level, accepting the reality of a situation, knowing when to say no to increased workloads, changing behaviour to avoid delaying personal needs, appropriate eating and sleeping habits, resting, and taking time for family and personal goals can help win the fight against burnout; team members also play an important role in its diagnosis and support. Occupational health and safety discussions, experience sharing, and development of interpersonal relationships are important. Establishing an occupational health program at the institutional level, developing mental health programs for early diagnosis and treatment, and establishing medical and psychological support during symptomatic events are necessary for fighting the burnout syndrome (20).

There is no doubt that taking institutional measures for situations, such as fires, earthquakes, and electric shocks, and planning what needs to be done in the event of an accident or when one is at risk are necessary for employee safety (27).

Anaesthesiologists are exposed to numerous potential risks that can harm their general health. These risks are the major mortality and morbidity factors in anaesthesiologists. Various preventive measures to be taken to ensure occupational safety in anaesthesia practices are extremely important for employee health. Providing a safe working environment and prioritizing the safety and satisfaction of the employees along with safe anaesthesia procedures will also provide patient safety. Raising awareness about occupational risks in anaesthesiologists will contribute to increasing occupational health and safety. National legislation needs to be developed to ensure the safety of anaesthesiologists. There is a need for structured national occupational safety laws and procedures for job safety in anaesthesiology with the support of the Turkish Society of Anaesthesiology and Reanimation.

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