HAZARDS OF ANAESTHESIA: A COMPREHENSIVE REVIEW

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ABSTRACT

BACKGROUND

A recent survey by WHO has revealed that 75% of the anaesthetists suffer from some kind of stress. Another study showed that 25% of professionals found to have substance abuse were anaesthetists. This implies that Anaesthesiology offers high occupational risk compared to other health care professionals.

OBJECTIVES

This articles aims to analyse the risks related to anaesthesia practice and measures to prevent and improve the degree of safety and quality of life at work.

CONCLUSION

The adverse effects of anaesthesia have decreased due to the increased vigilance by the Government and professionals. But it can be even further reduced by improved education and training to build knowledge and skills.

KEYWORDS

Occupational Exposure, Post exposure Prophylaxis, Quality of Life, Risk Factors, Inhalation Anaesthetics, Psychological Stress, Latex Hypersensitivity.

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INTRODUCTION: The long working hours and highly stressful environment of the routine anaesthesia practice adversely affects their overall health. Anaesthesiology is thus aptly categorised as a profession with "High Occupational Risk".[1] The World Federation of Societies of Anaesthesiologists (WFSA) conducted an international survey in 2010 in order to analyse the occupational risks and develop strategies to improve the quality of life.[1] They classified the hazards, according to the type of agent or situation that triggers them.[1]

Risks Related to Anaesthesia Practice:

Chronic Occupational Stress: Occupational stress is defined as the physical and emotional reactions that occur when the demands at work exceed the capacity, tolerance, resources and needs. Excessive stress impairs performance and decision making. Doctors belonging to Type A personality are more susceptible.[1]

I.	**Risks related to Anaesthesia Practice**
a.	Chronic Occupational Stress.
b.	Psychosocial disorders.
c.	Drug addiction.
d.	Ergonomics.
II.	**Risks related to biological agents**
a.	Blood-Borne infection.
b.	Airborne infections.
III.	**Risks related to safety and physical agents**
a.	Ionising radiation.
b.	Non-ionising radiation.
c.	Noise and vibration.
d.	Temperature.
e.	Ventilation & Lighting.
f.	Electric dangers (High and Low voltages).
g.	Fires.
h.	Compressed gas (Cylinders).
IV.	**Risks related to work standards**
a.	Organisation and type of work.
b.	Work Pattern.
V.	**Risks related to Chemical Agents**
a.	Latex Allergy.
b.	Exposure to inhaled anaesthetics.

Table 1: Classifications

FACTORS CAUSING STRESS
1. Lack of control of the work routine.
2. Conflict in the professional and personal relationships.
3. Problems related to organisational and administrative work pattern.
4. Management of critical patients.
5. Jeopardised family Life.
6. Professional expectations.
7. Insecurity of Job.
8. Medico-legal issues such as potential litigation.
9. Sleep deprivation & disruption of circadian rhythm.

Table 2: Factors Causing Stress.[1]

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a.	Physical diseases - Chronic fatigue, Peptic Ulcer, Gastritis, Hypertension, Arrhythmias, Angina, Reduced immunity, Reproductive disorders.
b.	Psychological Disorders- Anxiety, Depression, Suicidal tendency.
c.	Behavioural Disorder – Alcohol and Drug Abuse, Psychotropic drug use, Drug abuse, Aggressive behaviour.
d.	Intellectual Changes – Difficulty to concentrate, Impairment vigilance, Reduced work performance.

Table 3: Effects Caused by Prolonged Stress

Early diagnosis and medical and psychological treatment in symptomatic cases are essential. Appropriate work schedules, adequate work infrastructure, occupational protections and improvisation of the work place and maintenance of work-family-social life balance improve the quality of life.

Chronic Fatigue and Burnout: Anaesthesia is a career that involves excessive working hours with a lot of overtime and night shifts. Inappropriate work schedules cause sleep and circadian rhythm changes. The human body is genetically programmed to sleep from 1 am to 7 am and from 1 pm to 4 pm with higher levels of alertness from 9 am to 11 am and from 9 pm to 11 pm. The period between 2 am and 4 am is the time when the circadian cycle is at the lowest.[1,2]

There are Three Types of Fatigue:

1. **Transitional:** Caused by mild sleep deprivation or prolonged periods of sustained attentiveness.
2. **Cumulative:** Caused by moderate sleep deprivation or extra hours of alertness over many consecutive days.
3. **Circadian:** Professional performance in diminished during the night, which is specifically dependent on the circadian cycle.

Burnout syndrome occurs on prolonged exposure to severe stress. It has been defined by Freudenberger and Maslach as the combination of specifically work related fatigue, emotional exhaustion and depersonalisation.

Effects of Chronic Fatigue and Burnout:

1. Changes in the circadian rhythm lead to alterations in digestion, sleep, body temperature, adrenaline secretion, blood pressure, heart rate and behaviour.
2. Mood disorders, headache, depression, dizziness, loss of appetite and digestive problems.
3. Irregular menstrual cycles, premature labour, intrauterine growth retardation, small-for-gestation babies, pregnancy-induced hypertension.
4. 'Sleep deficit' due to cumulative sleep deprivation especially REM-Sleep. The individual may experience 'Microsleeps' which are brief uncontrolled spontaneous episodes of physiological sleep lasting for seconds or minutes.
5. Sleep deprivation affects the capacity for analysis, thought formation and decision making e.g. ECG interpretation. The integration of logic and manual skill is affected as evidenced by reduced agility and precision in procedures (e.g. intubation skills).
6. Reduced patient safety and increased possibility of "Human Error", due to impaired decision making.
7. Alterations in the release of hormones (Cortisol, catecholamines).
8. Poor immunity.[1,2]

Prevention: Maintaining a good sleep pattern, regular exercise and good nutrition is of utmost importance. The sleep inertia can be overcome by increasing the light levels, stretching, walking briskly and taking refreshments like caffeinated drinks. The following recommendations may be borne in mind when developing the work system.

- Working no more than 48-50 hours/wk.
- Not working more than 5 or 6 hours without small breaks in between.
- Not working more than 10 consecutive hours per day.
- Avoiding more than 2 overnight shifts of 12 hours per week.
- Distributing days off evenly.
- Not working for 2 consecutive shifts.
- Well-structured rest room.[1,3]

Psychosocial Disorders: Various studies have demonstrated an increase in the anxiety disorders and suicidal tendencies among anaesthetists compared to the general population.[4-7] Dr. Horace Wells (A mentor of modern anaesthesiology) committed suicide in 1848.[1] Contributing factors include Type A personality, stressful nature of the profession, genetic predisposition, underlying mental illness and easy access to drugs.[2] A pre-employment as well as periodic health examinations (Every 5 years with increasing frequency with advancing age) should be conducted. Physicians with suicidal tendency must be recognised.

Chemical Dependence:

1. Substance abuse and chemical dependence have acquired an important dimension in the current anaesthesia practice. Factors predisposing the anaesthetists to substance abuse include genetic predisposition.
2. Working Pattern – Anaesthetists are usually required to work alone for long, monotonous hours.
3. Personal problems like marital discord, financial issues, and family problems.
4. Easy access to potent sedatives and psychoactive drugs.
5. Risky nature of the profession.
6. Chronic subtherapeutic exposure to second-hand drugs (Fentanyl, Propofol and volatile agents are exhaled by the patient in small amounts during recovery of anaesthesia). These may induce neuronal pathways that predispose to addictive behaviour.[2,8]

Signs and symptoms are insidious in onset. The job performance is often last to be affected. Direct observation of self-administration confirms the diagnosis.

Chemical Dependency can be reduced by:

1. Rigid control of drug dispensing and return.
2. Random testing of all Anaesthesia personnel.[1]

All personnel must be educated in early identification and treatment of addicted individuals. Protocols allowing confidential reporting of suspected drug abuse must be followed. Risk of relapse must be borne in mind.

Ergonomics: The wide array of monitors and electrical equipment in the OR brings along with it a cacophony of alarms and beeps. Each sound stimulates the anaesthetist's brain and consumes energy.[9] Sustained vigilance is one of the key aspects of the speciality. Our surveillance ability decreases rapidly and is exhausted after 30 minutes of continuous monitoring.[1] Strain injury may occur especially in the first metacarpal joint due to continuous mask ventilation and repeated aspiration and injection of drugs. These can be reduced to some extent by using laryngeal mask airway or endotracheal tube to secure the airway. Lacerations occurring while opening glass ampoules can be minimised by using plastic ampoules and ampoule snappers.[2]

Another often overlooked issue is the backache experienced by the anaesthetist. This occurs due to improper positioning while securing airway, administering blocks, securing cannulas and while transferring patients from bed to trolley or operative table. This can lead to disc problems in high risk individuals.[8] A good and comfortable positioning must be adopted while performing procedures. Safe manual handling must be followed while transferring patients. Whenever possible the patent should be encouraged to move independently. For the dependent patient, a minimum of four handlers are required. If needed, use a roller.

Principles of Safe Manual Handling Include
Avoid manual lifting.
Get close to the patient and the load.
Face the direction of movement. Avoid twisting.
Keep the back upright, Avoid stooping.
Ensure your feet are apart, one foot in front of the other (Walk Stance)
Ensure a secure hand grip Use the commands 'Ready, steady, move'. Numbers can be confusing as some may move on 'three' and some on the unspoken 'Four'

Table 4: Principles of Safe Manual Handling[3]

Checklists and protocols along with use of colour-coded, standard-format labels, for each drug improve the performance of anaesthetists and prevent drug administration errors Latest monitors are equipped with both audio and visual alarms. Anaesthetists working for continuous periods must be encouraged to take short breaks.

Risks Related to Infections Blood Borne Infections: These include Human Immuno Deficiency Virus (HIV), Hepatitis B and Hepatitis C and are transmitted by needle pricks and contact with infected body fluids.[2,8]

HIV Infection: The average risk for transmission is 0.3% after percutaneous exposure to infected blood and 0.09% after contact with mucosa.[1,3] CSF, synovial fluid, peritoneal fluid, pleural fluid, pericardial fluid and amniotic fluid are potentially infectious fluids. Faeces, saliva, sputum, sweat, tears, urine and vomitus are not considered infectious unless they contain blood.[8]

Preventive Measures Include:

1. Wearing double gloves.
2. Wearing masks, goggles, aprons and boots.
3. Avoid resheathing needles.
4. Sterilise all equipment in Ethylene oxide or hydrogen peroxide.
5. Avoid mouth to mouth resuscitation.
6. Transport contaminated materials in leak proof containers.
7. Proper disposal of used needles and catheters.[2]

Post-Exposure Prophylaxis (PEP):

In case of exposure, one should

1. Wash the area vigorously with soap, water and disinfectant solutions.
2. Rinse eyes with water or saline solution.
3. Perform serological testing in the patient.
4. Perform serological testing in the professional every 6 months for 2 years.

The anti-retroviral therapy must be initiated at the earliest.

Type of Exposure	Type of Patient Material	PEP Regime
Superficial lesions Injuries with solid needles	Type 1 • Asymptomatic • Low viral load	2 classes of drugs
	Type II • Symptomatic • Acute Seroconversion • High viral load	3 or more classes of drugs
Mucous membrane or skin lesions to small amount of contaminated blood	Type I	2 classes of drugs
	Type II	2 classes of drugs
Mucous membrane or skin lesions to large amount of contaminated blood	Type 1	2 classes of drugs
	Type II	3 classes of drugs

Table 5: PEP Regime in HIV infection[1]

PEP is not recommended when there is no serology (deceased patient) and for accidents involving patients with negative serology. However, in case, the deceased patient had risk factors for HIV, PEP with two drugs can be started.

Moreover, in accidents resulting in serious injury and/or with large amount of blood contamination, PEP is modified to 3 classes of drugs, even if the patient is asymptomatic with low viral load. The indicated PEP Regime should be initiated as quickly as possible and reassessed 72 hours after exposure. Medications should be administered for 4 weeks if tolerated. They should be discontinued if the serology turns out to be negative. Due to the toxicity of the agents, one should always weigh the risk/benefit ratio of PEP, especially when 3 classes of drugs are to be used. The exposed professionals must undergo serology tests at least once at 6 months post exposure (6 weeks, 12 weeks and 6 months) or when facing an acute retroviral syndrome.

Hepatitis B: The risk of transmission is 40-60% (20-60% from HBeAg +ve source or replicating) and (6 – 35% from HBeAg-ve source or non-replicating). Milk, bile, CSF, faeces, nasopharyngeal secretions, saliva, sweat, and synovial fluid are poor transmitters of HBV.[1,2] In case of accidental exposure, one should stop the procedure and wash the wound exhaustively with soap and water. Antiseptic solutions such as chlorhexidine may be used. Local injections and irritant solutions such as ether, hypochlorite and glutaraldehyde are contraindicated.

Unvaccinated Health Care Professional			**Vaccinated Health care Professional (Anti HBS >10 mIU/mL)**		
HBV +ve Source	HBV – ve Source	Unknown or untreated Source	HBV +ve Source	HBV – ve Source	Unknown Source
Immunoglobulin + start vaccination regime	Start vaccination regime	Start vaccination regime	No Specific Measures		

Table 6: PEP Regime in Hepatitis B Infection[1]

Hepatitis B vaccine is given as a regime of 3 doses at 0, 1 and 6 months. However, 10% of the population do not respond to three doses. A repeat 3 dose course can be administered in such cases. All health care professionals must be vaccinated as a pre-exposure measure. The vaccine is safe in pregnancy and lactation.

Hepatitis C: Blood is the only effective transmitter. The average incidence of seroconversion after percutaneous exposure to infected blood is 1.8% (Range 0-7%). In cases of accidental exposure, the wound is to be washed thoroughly with soap, water and an antiseptic solution.

PEP Regime: There is no effective vaccine. The exposed professional should be monitored serologically up to 1 year. Liver enzyme testing and PCR/RNA must be done. Precautions such as usage of condoms, avoidance of pregnancy and blood donation, discontinuation of lactation must be strictly taken.

Airborne Infections: Anaesthetists, as specialists in airway management, are exposed to airborne infections especially during procedures like bronchoscopy, laryngoscopy, intubation, airway suctioning and mechanical ventilation. The airborne infections include tuberculosis, influenza, SARS, coronavirus and rhinovirus. These spread by small droplets (1-5 u).[2,8]

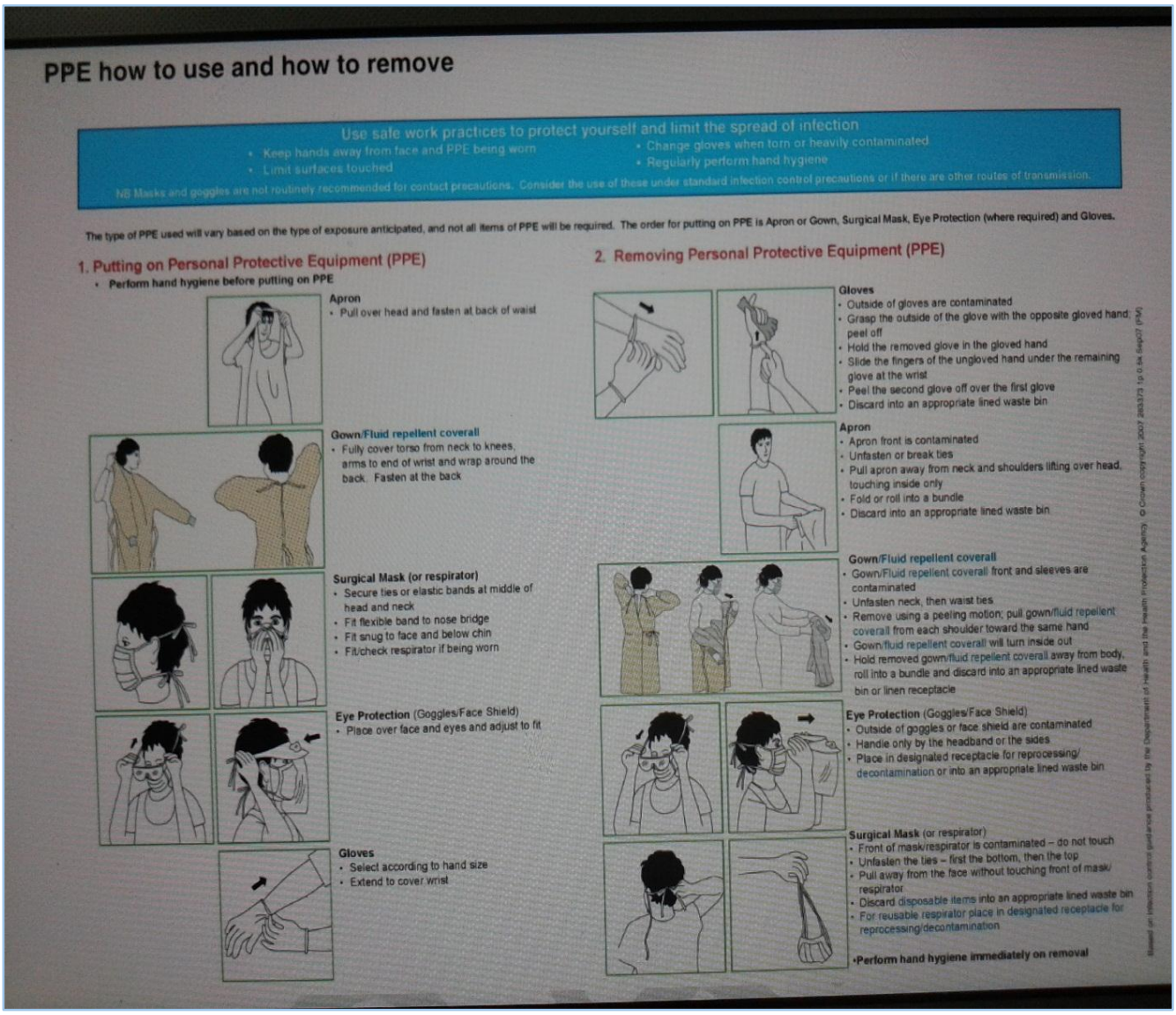
Prevention: Elective procedures must be delayed till the patient is non-infectious.

Protective Strategies Include:

a. Immunisation.
b. Personal Protective Equipment.
c. Hand Hygiene.[3]

Immunisation: Immunisation against influenza is recommended annually due to the changing nature of the virus. BCG vaccination is available for professionals with suspected exposure.

Personal Protective Equipment (PPE):



Appropriate precautions such as wearing fluid repellent surgical mask should be used while assessing patients with respiratory infections of unknown case. If there is a likelihood of splash onto mucous membrane, an additional mask, gloves, and gown may be used. If an aerosol generating procedure (bronchoscopy, tracheal intubation, cardiopulmonary resuscitation, high frequency oscillating ventilation, non-invasive ventilation) is to be undertaken, a filtering face piece (FFP3) mask must be used, besides the routine eye protection, gloves and gowns. A FFP3 device is a mask that provides the wearer with a high level of protection against airborne infections. These masks fit snugly around the face and allows air passage only through the filter. For effective use, the wearer must be 'fit tested' to ensure that the mask fits properly.[3]

Hand Hygiene: It remains the most important infection control measure. Clean hands may be decontaminated using alcohol gel between patient contacts. If the hands are visibly contaminated, wash hands with soap and water.

Post Exposure Prophylaxis: Prophylaxis with oseltamivir for 5 days may be offered to individuals exposed to influenza (Swine Flu).[8,10] In situations of suspected exposure to Tuberculosis, a tuberculin test must be done. If it turns out to be positive, 6-12 months of chemoprophylaxis with anti-TB drugs is indicated.[8,10] There is no post-exposure antidote for SARS and other novel corona viruses.

Risks Related to Radiation Exposure: These types of risks are more in present day anaesthetists as interventional procedures done under anaesthesia become more common.

IONISING RADIATION:

Exposure to Ionising Radiation: This occurs while taking radiographs, CT scans and during administration of radio isotopes, with maximum risk from fluoroscopy. Occupational exposure to radiation does not usually reach more than 10% of the maximum dose of 5 REM. A single X-ray exposes patients to 25 mREM, far below the toxic levels. The use of fluoroscopy with an energy of 1.5 mAMP for 10 minutes is equivalent of 69 CxRS.[1]

The amount of exposure to ionising radiation depends on the distance between the radiation source and the individual. Radiation can be reflected by surfaces, increasing exposure levels and occupational risk for people inside the room. The effects of radiation are cumulative. The maximum dose allowed by the International Commission on Radiological Protection, expressed in REM units is 100 mREM/Week and 5 REM/Year.[1] Hazards include leukaemia, thyroid malignancy, cataract, germ cell mutations (especially in women), increasing the chance of malformation. The exposure can be minimised by using protective lead jackets, thyroid covering collars and maintaining safe distance from the radiation source.[8]

Exposure to Non-Ionising Radiation: This occurs during exposure to laser and microwaves. Laser devices are internationally classified as:

Class I	Sources that do not exceed the Maximum Permissible Exposure (MPE)	Not visible to the eyes
Class II	Lasers with visible beam sources with energy up to 1 mW	Eyes are protected by blinking reflex every 0.25 sec
Class IIIa	Sources with energy up to 5 mW	Eyes are protected by blinking response
Class IIIb	Sources with energy up to 500 mW	Direct vision is dangerous
Class IV	Sources of more than 500 mW	Extremely dangerous for eyesight

Table 7: International Classification of Laser Devices[1]

Most laser equipment in the operating room are class IV.

The deleterious effects caused by non-ionising radiation are due to its intensity and by-products released during tissue destruction. Eyeball injuries (corneal and retinal burns optic nerve damage and cataracts) are frequent. Although skin is less vulnerable than the eyes, exposure to high intensity radiation can cause burns and mutagenesis. The ill-odoured smoke released during tissue vaporisation is mutagenic. The presence of high oxygen concentrations may ignite a fire.[2]

Protective eyewear with special filters should be used. Continuous renewal of the air inside the surgery room is important. Flammable anaesthetics must be avoided as for as possible. The oxygen concentration must be less than 25%. Special non-flammable endotracheal tubes and instruments with non-reflective surfaces must be used.

Special Situations Ultrasound: These devices are not sources of radiation. No radioprotection is needed.

Radiographs inside the ICU or Operating Room: These devices have low kilovoltage and milliamperage. There is usually a remote control and long wires, around 2 m. No extra radio protection is needed if the health personnel are able to remain beyond 2 m of the source.

Tomography Rooms: CT scanners are large X-ray equipments and therefore, release ionising radiation. Radioprotection needed.

Fluoroscopy Rooms: These equipment release continuous ionising radiation throughout the procedure. Radio protection is needed.

Magnetic Resonance Imaging: Exposure to intense magnetic fields cause malfunctioning of implanted ferromagnetic items e.g. pacemakers, aneurysm clips. Stimulation of the semi-circular canals causes nausea and vomiting. The acoustic noise produced by the vibration of the working coils may exceed the safe levels. Large volumes of helium gas released during quenching of the magnet may lead to hypoxia. 'Quenching' is the rapid boil-off of the cryogen, usually liquid helium occurring due to system failure or rapid shut-down of the magnet.

These undesirable effects may be minimised by remaining in the control room during the scan. All professionals must be screened for the presence of ferromagnetic items. Those remaining in the examination room during the scan must wear ear protectors. Gases released during quenching must be vented out safely.[1,2]

Risks Related to Chemical Agents: Toxicity depends on the concentration, respiratory index (average amount of air inhaled by the individual in a work day), individual sensitivity and exposure time.

Waste Anaesthetic Gases: Nitrous Oxide and inhalational agents, which are released into the environment damage the DNA, organelles and plasma membranes, by causing oxidative stress. Exposure to high concentrations even for a short time can cause headache, irritability, fatigue, nausea, drowsiness, difficulties in judgment and coordination, hepatic and renal disease. Studies have demonstrated an increased incidence of miscarriages, malignancies, chromosomal defects in offspring's in populations with longterm exposure to waste gases.[11] A reduction in the B-lymphocytes and Natural killer cells was noted. However, there was an increase in the immunoglobulins.[12] Systemic involvement includes respiratory (acute rhinitis, laryngitis, chronic bronchitis, asthma), cardiovascular (arrhythmias, conduction disturbances, ischaemia) and gastrointestinal (chronic hepatitis, peptic ulceration, cholecystitis).[13,14]

The National Institute for Occupational Safety and Health (NIOSH) states that it is impossible to define a safe level of exposure to volatile anaesthetic agents and recommends the greatest possible reduction, with upper limits of 2 ppm for halogenated agents and 25 ppm for nitrous oxide.[14,15] When both types of anaesthetics are used in combination, the limit for halogenated agents is reduced to 0.5 ppm.[16] The maximum concentration recommended by

the NIOSH is several times lower than the least concentration recognised by the human olfactory system- few people are able to perceive concentration of 33 ppm.

Therefore, if the odour of the anaesthetics can be sensed in the OR, their concentration is well above the recommended levels.[15] The occupational risk extends to the post anaesthesia care unit (PACU), since patients continue to exhale volatile agents for 5-8 hours after the end of the anaesthesia.[14,15]

The leaks may be minimised by using well-fitting face works, LMAS, cuffed endotracheal tubes and throat packs. Use low flows whenever possible.[15] Personnel who work in areas of high exposure (e.g. dental, paediatric ORs) should be rotated on a regular basis.[13]

Agents	Effects	How to Minimize
Latex	Hypersensitivity Type reactions – range from localised oedema to anaphylactic shock and death Type IV Contact dermatitis Non-Allergic reactions skin irritation.	Wear gloves with low latex content Use Latex free products Hand washing after contact with latex products
Surgical Smoke	Contain significant amount of intact viruses, viable tumour cells and Carcinogens like Acetaldehyde, Benzene, Carbon Monoxide can precipitate ischemic heart disease.	Use suction devices Note: Standard surgical masks do not provide adequate protection.
Alcohol Chlorhexidine	Skin irritation, urticaria	Minimise duration of Exposure Use dilute solutions
Glutaraldehyde	Headache, nausea, soreness of throat, conjunctivitis, respiratory discomfort, urticaria, dermatitis, brownish discoloration of skin	Minimise usage
Ethylene Oxide	Skin irritation, conjunctivitis, corneal abrasion, allergic reactions, nausea, drowsiness, seizures	Air Equipment after exposure
Formaldehyde	Carcinogenic-Leukaemia, Nasopharyngeal carcinoma Eye, nose, throat irritation; contact dermatitis, pulmonary oedema, pneumonia	Limit exposure Use fume exhaust systems
Methyl Methacrylate (Bone Cement)	(= Powerful irritant, corrosive chemical) Emphysema, Pneumonia, Pulmonary Oedema, Haemorrhage	Use fume exhaust systems

Table 8: Commonly Exposed Chemical Agents.[1,2]

Chemotherapy: Cytoreductive surgery involves long periods of peritoneal and visceral resection using high voltage electrocautery which generates a significant amount of aerosolised particles in the OR. This is often followed by Hyperthermic Intra-Peritoneal Chemotherapy (HIPEC) where warmed anticancer drugs are infused into the peritoneal cavity. Routes of exposure are ingestion, injection, contact and inhalation. Toxicity is related to intensity and duration of exposure. Blood and body fluids are considered contaminated for 48 hours after last dose. Affected skin should be washed with soap. If eyes are affected, flood with water or saline for 15 minutes.[17,18]

Protective Measures Include:

In case of spillage	Use absorbent plastic-backed pads, clean with 70% alcohol thrice followed by routine cleaning
• Personal protection	Disposable long-sleeved aprons, impervious shoes, goggles, face shield, unpowdered elbow length latex gloves, work below eye level
• Environmental measures	Adequate air ventilation and smoke evacuators
• Storage	Use leak-proof containers labelled 'Cytotoxic Agents'

Table 9: Measures to Minimise Harmful Effects of HIPEC.[17,18]

CONCLUSION: Thankfully, the adverse effects of anaesthesia have diminished due to the increased vigilance by the government and professionals. I hope this article provides a better understanding of the hazards of anaesthesia and thus enhance early recognition. Let's not forget what our forefathers taught us "To Be Aware of the Problem Is the First Step to Its Solution".

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