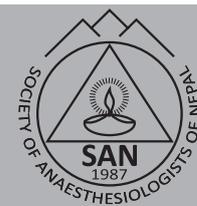


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Review Article

Risk for the surgical team during orthopaedic surgeries

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Abstract

Orthopaedic surgeons and the surgical team not only face health hazards faced by most of the physicians in any medical field but also hazards specific to the practice of orthopaedic surgery. Common health hazards are related to radiation, infections, surgical smoke, noise, chemicals, physical and it may be psychological. The aim of this article is to review the hazards and raise the awareness for the safety of orthopaedic surgeon and the surgical team as well as patient and newly introduced surgical team member in Operation Theater.

Keywords: Health hazards; operating rooms; orthopaedic procedures; radiation



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Introduction

A surgical team is made up of the surgeon, surgeon's Assistant, anesthesiologist, circulating nurse and surgical technologist. The orthopaedic surgical team must have an idea about health hazards from the operative procedure, anaesthesia, implants, instruments, equipment, operation room, and also how to be safe

from such hazards during surgery such as radiation, blood spray, trauma by heavy implants and instruments. In the resource-limited country like Nepal, we are not equipped with latest equipment, instruments, Operation-theater, implants and surgical techniques but we try to give the best result to our patients as well as trainee students.

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Safety concerns are of prime importance regardless of the setup and financial position. This article reviews critical aspects of health hazards and safety measures inside the orthopaedic operating rooms. The major hazards are as follows.

Radiation hazard

The orthopaedic surgeon uses intra-operative imaging much more often than other surgical specialists. Fluoroscopy imaging is particularly indispensable during surgical management in the operating room which may expose the trauma surgeon and surgical team staff to dangerous doses of radiation. Even relatively small doses should be considered dangerous over the long period of time. Direct correlation between exposure and operative time has been noted. Procedures that often require intra-operative fluoroscopy include fracture reduction, intramedullary nailing, percutaneous cannulated screws, Kirschner wire, external fixator pin placement, location of guidewire, hardware and foreign body removal, stability assessment, guidance bone biopsy and cyst aspiration.¹⁻³ We perform these procedures routinely in our operation theatres.

The effect of radiation can be categorised into dose-dependent (non-stochastic) and dose-independent (stochastic). Chromosome damage is related to stochastic effect. In somatic cells, it can lead to cancer whereas germ cells can lead to genetic defects in offspring. Similarly, large exposures of radiation to the gonads may lead to infertility and birth defects, including anencephaly, leukaemia, spina bifida, congenital cataracts, small head circumference and low birth weight. The perceived level of personal risk for cataract formation from ionising radiation exposure accumulated over the course of their careers. Nonstochastic effects appear and stay for hours or days after exposure and can induce erythema, burns, sterility, and radiation sickness.¹⁻⁴

Radiation exposure can be monitored with three main types of recording devices: film bandages, thermoluminescent dosimeters (TLDs) and pocket dosimeters. National Council on Radiation Protection and measurements (NCRP) recommends maximum annual total body dose of 5-rem and the international commission of radiological protection recommends 2-rem. Minimise radiation technique is dependent on surgeons skills and experience as well as the experience of the surgical team. Radiation exposure can be reduced by 99% using 0.5mm lead apron whereas 90% reduction can be achieved with 0.25mm material. Others protections from radiation depends on distance 3 feet from the source, adequately trained operator, staff training, well-planned procedure, pulse mode, memory storage, the position of the C- arm, exposure time alarm, equipment related factors and mini C-arm. One should always remember Dr Marie curie, inventor of modern radiology and a double Nobel laureate, died of radiation-induced pernicious anemia.^{3,5-7}

Infection hazard

Surgeons and health-care workers have always been at high risk of exposure to blood-borne diseases in their occupation. In orthopaedic surgery, infection is spread mainly by contact transmission i.e., percutaneous or mucocutaneous exposure to blood-borne pathogens. The use of sharp instruments, including drill, reamer, K-wire, saws, suture needle etc and sharp bone handling by the Orthopaedic surgeons have put them at high risk of blood-borne infection. Knowledge of transmission of infectious diseases is very important in the prevention of occupational transmission of pathogens. Contact, droplet, and airborne routes are the main cause of microorganisms transmitted in hospitals. Contact transmission can be direct and indirect. Direct body-to-body contact with the patient during surgery is an example of Direct-contact transmission whereas transmission of pathogens by contact with contaminated objects such as needles and instruments is an Indirect contact transmission.^{1,8}

Some microorganism may be resistant to the standard sterilisation process and can transmit diseases such as HIV, HCV, Hepatitis B, Tuberculosis and Prion disease. The mucous membrane of the eyes, nose, or mouth or contact of the skin with the blood spray from infected patients during use of power tools and irrigation exposes the surgical team to the mucocutaneous contact.^{5,9}

After a single percutaneous exposure to Hepatitis-B virus in an unvaccinated person, the risk of acquiring infection ranges from 6% to 30%. Hepatitis- B virus in dried blood at room temperature on the environmental surface can survive for least one week. So, vaccination for hepatitis-B is the best way to prevent hepatitis-B infection. HBV may get transmitted relatively easily to the healthcare personnel from infected patients when compared to HIV infection. Surgeon status for HBV antibody is very important in post-exposure prophylaxis (PEP) management since strong positive antibody test determines the safety of the surgeon. If a surgeon is weakly positive or is non-reactive for the surface antibody, administration of a dose of HBV immunoglobulin is must and a booster dose of HBV vaccine to be given immediately. For the exposed persons who are not immunised before exposure and are seronegative for HBV surface antibody, then a dose of HBV immunoglobulin should be given; followed by full vaccination series immediately.^{8,10}

The hepatitis-c infection has become a greater source of concern due to unavailability of effective vaccination. A large number of people in society carry chronic HCV infection and the rate of chronic infection that follows and an acute episode is high despite the low frequency of transmission (1.8-7%) with percutaneous exposure.¹⁰

The risk of HIV infection due to a single percutaneous injury is estimated to be 0.3% (95% confidence interval = 0.2% to 0.5%) whereas risk of infection after exposure of a mucosal membrane 0.09% (95% confidence interval = 0.006% to

0.5%).¹⁰ Other factors which associate with increased risk of HIV transmission are the depth of injury, visible blood on the device that causes the injury, the quality of blood injected, the bore of the needle, exposure to a patient with acquired immunodeficiency syndrome or high plasma viral burden. The use of gloves decreases the volume of blood injected by solid needles by 70%, while the second layer of gloves reduces more than 50%.¹⁰ Transmission of HIV due to the exposure involving small amounts of blood on intact skin has not been documented. Though it is generally a percutaneous or mucous membrane exposure, it requires PEP along with antiretroviral chemoprophylaxis. Similarly, during irrigation of tuberculous abscesses of the hip and thigh with saline solution, Tuberculosis may also be spread through inhalation of aerosols generated during such procedures. Following universal precautions such as routine wearing gloves, gowns, cap, mask, goggles and boots for procedures where contacts with the microorganism expected are mandatory. Similarly, wearing double gloves and waterproof aprons to prevent splattering blood and bloody fluid is highly recommended. One should also use no touch technique of handling sharps and the assistants should be properly trained. A presurgical briefing and discussion of possible health hazards may reduce the chance of transmission of infections.^{8,10,11,12}

Noise hazard

Noise is unavoidable in the operating room environment. Along with water and air pollution, some consider noise as the third major pollution. The noise pollution causes stress to the surgical team, may cause hearing loss, tinnitus, patient and physician anxiety and distraction from the surgical procedure. The level of noise produced during orthopaedic surgery is higher than our normal conversation (50dBA) and may lead to a significant hearing loss. For daily noise exposures of 80 dBA to 85 dBA, NIOSH (National Institute for Occupational Safety and Health) considers the risk of material hearing impairment to be 1% to 8% over a 40-year working-time. According to the safety recommendation by Occupational Safety and Health Administration (OSHA), one should use protective device during exposure of continuous sound intensity of minimum 80 dBA and if the duration is 8 hours.^{5,13}

Operating room gets noisy due to both types of equipment and staffs, the major factors include phone rings and conversations. Equipment includes anaesthetic monitor, suction machine, electric drill, cautery machine, hammer, metal to metal contact or dropping of metal instrument. The easiest and most effective solution is to minimise the noise production. Surgical team should clearly communicate so that other team member can understand and minimise irrelevant conversations. Mobile phone should be in silent mode. To minimise the noise level one should make sure that existing instruments are operating as quietly as possible, and check them periodically. Regular servicing of the instruments is mandatory to make them work safely. Instruments should be replaced or repaired if

it gets noisy. Experienced nurse or assistant should handle the implants and instruments.¹⁴

Surgical smoke hazard

There are various names for the Surgical smoke; cautery smoke, plume, diathermy plume, smoke plume bio-aerosols, aerosols, vapour and air contaminants. Smoke produce during cauterisation contains approximately 85% water vapour and 5% chemicals and cellular debris which may be harmful to surgeons and staff. Smoke produces overall particles ranging from 0.05 µm to larger than 25 µm. The evidence suggests that the surgical smoke particles are of respirable size. Particles below 10 µm are inhaled whereas particles 2.5–10 µm in size are deposited in the respiratory tract.^{1,15}

Surgical smoke contains chemical carcinogenic or mutagen (acetaldehyde, hydrogen cyanide, formaldehyde, styrene, toluene, ethylene, ethane, methane, phenol, xylene, benzene, carbon monoxide, etc.), blood and tissue, the viruses and bacteria. The risks of Surgical Smoke contains viruses and bacteria such as hepatitis, human immunodeficiency virus, human papillomavirus, *Bacillus subtilis*, *Staphylococcus aureus*, and *Mycobacterium tuberculosis*. There can be acute and chronic inflammatory changes in the respiratory system (asthma, emphysema, chronic bronchitis), sneezing, hypoxia, confusion, nausea, vomiting, headache, weakness, lightheadedness, dermatitis, carcinoma due to smoke. It also causes lacrimation, cardiovascular dysfunction, eye and throat irritation, colic, anxiety, anaemia, leukaemia, nasopharyngeal lesions, etc. The volume of surgical smoke depends on the type of tissue, type of procedure and technique, the amount of tissue ablated, ventilation system and type of smoke evacuators. Protection from smoke can be achieved by using proper suction devices, distance from smoke generation and direction of room air or smoke flow, modular operating rooms and the use of proper personal protective equipment such as masks, goggles.^{1,16,17}

Chemical hazards

Volatile anaesthetics agent such as halothane, NO₂, isoflurane desflurane and enflurane has a harmful biological effect on our body which is absorbed through the alveolar capillary membrane. Volatile anaesthetics are rarely used alone nowadays. A combination of inhalation anaesthetics along with intravenous drugs is more commonly used. Total intravenous anaesthesia has gained more popularity in recent years; however, halogenated gases are still used to maintain narcosis. In some cases, for instances, during pediatric anaesthesia, or cases where we are likely to face difficult intubation, inhalational anaesthetic techniques are often chosen, in order to avoid can't intubate, can't oxygenate situation. Volatile anaesthetic agents are highly lipid-soluble. They are metabolized in the body; and the metabolites excrete more harmful effect that can potentially cause hepatic,

renal, and pulmonary toxicity and decreased psychomotor efficiency on chronic exposure to these agents. Though, we all know issues, have been raised from time to time regarding the teratogenic effects of anesthetic gasses and the resultant congenital abnormalities in the newborn as well as a higher rate of spontaneous abortion among female anesthesiologists but so far nothing conclusive has been established as yet. Many anesthesiologists prefer to perform orthopedic surgery under spinal anesthesia or regional nerve blocks.¹⁸⁻²⁰ It is a good strategy to reduce exposure to anesthetic chemicals.

Polymethylmethacrylate (PMMA) has been widely used as the cement fixation of orthopaedic prosthetic devices. The surgical team is the one to face the most risk for exposure of skin, respiratory tract, and neurologic system due to toxic effects of PMMA.^{1,21} Formaldehyde and Glutaraldehyde are used for sterilisation of orthopaedics instruments and implants especially thermal-sensitive instruments. In our operation theatres, containers of formaldehyde or Cidex of Glutaraldehyde are present for sterilisation of some instruments and implants such as electric power drill, K-wire, suction tube, cautery wire. Exposure to Glutaraldehyde on regular basis or accidental ingestion can cause irritation to the eyes, skin, and respiratory system. It can also cause dermatitis, sensitization, cough, asthma, nausea, and vomiting. Glutaraldehyde may affect the body through skin absorption, inhalation, ingestion, and skin and/or eye contact. Formaldehyde exposure also causes irritation to the human respiratory tract, loss of vision, cancers of the nose and lung. Due to regular exposure to formaldehyde one gets less sensible to sense of smell and eye irritation become less sensitive with time as one adapts to formaldehyde exposure; therefore, one cannot rely on formaldehyde's warning properties to alert oneself to the potential for overexposure. The type and degree of beneficial or adverse health effects are dose and exposure dependent.^{22,23}

Physical hazards

In Nepal due to increased number of road traffic accidents, trauma and population the demand for orthopaedic services has been increased exponentially, resulting in a shortage of orthopaedic surgeons. Orthopaedic surgery requires many hours of work in body positions known to contribute to musculoskeletal injuries. There are certain risk factors such as static stress (e.g., prolonged standing and fixed postures, holding equipment such as retractors during the surgical procedure) and manual handling (e.g. pulling/pushing or lifting instruments sets, patients and heavy equipment). The surgeon may not always be able to stand comfortably around the surgical table. This may cause physical stress, discomfort or, in extreme cases, injuries. Standing in the same positions may cause pain in the back, neck, shoulders, arms and hands. Orthopaedic surgeons may suffer from herniated discs in the neck, damaged muscles in the shoulder, back pain, tennis elbow and even varicose veins, carpal tunnel syndrome. Some

orthopaedic procedures are physically demanding for surgeons, requiring them to move, manipulate and hold heavy parts of patients steadily.^{24,25}

Either it is an open surgery or a minimally invasive surgery (Arthroscopy), surgeons has to maintain the static posture for long periods of time. Surgeons generally flex their necks and shift their weight, which can adversely affect the vertebral column and precipitate low back pain. During prolong surgeries, maintaining these static positions for long periods of time results in rapid fatigue, muscle pain, and cramping, and strain that can persist even after the operation is complete.^{26,27}

Psychological hazard

Stress and burnout have a remarkable impact on patient care and it may increase chances of medical errors. Physical and psychological job stress and mind-body arousal demands off-time for the physicians. Strain causes physiological, behavioural (e.g., substance abuse), and/or psychological (e.g., burnout) deviation of the human body from healthy functioning. The strain is distress or bad stress. In today's industrialised world Stress has been linked directly or indirectly to seven out of ten leading causes of death. However, stress is also directly linked as a risk factor for heart disease, stroke, injury, suicide, and homicide. Orthopaedic surgeons and surgical team need to be competent in all these aspects. So, they should not only be intelligent, but they must also have strong training, mentoring, and experience.^{29,30}

The burnout syndrome has been defined as a state of physical emotional or mental exhaustion caused by long-term involvement in situations that are emotionally demanding. We all know that due to increasing number of surgeries and lack of surgeons, staff shortage, high work overload, surgeons frequently experience stress, burnout, emotional exhaustion, depersonalization, and reduced personal achievements at the workplace. Specialists working in low and middle-income countries are possible at a higher risk. The factors responsible for stress and burnout among surgeons also include poor remuneration and conflicting values, insufficient rewards, lack of a sense of community, lack of fairness, feelings of ineffectiveness, highly demanding jobs, long working hours, competition and empathy. Orthopaedic training and practice has become a physical, mental and emotional challenge due to its responsibility involving serious consequences of made decisions and increased the pressure of avoiding mistakes. Non-work related factors include age and sex, marital status, and work-family conflict.^{31,32,33}

Conclusion

A well-planned surgery plays a key factor for minimising risk during surgery. The surgical team must have knowledge about operative procedure, implants, instrumentation and operation room condition. We can reduce the hazard both to the surgical team and patient by minimising each and

every factor causing it during surgery and implementing it to our day to day practice. A team debriefing before the surgical procedure and discussing the possible hazards may also reduce the risk of the danger associated with the surgical procedure.

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