Cumulative Radiation Exposure

Cumulative Radiation Exposure refers to the total amount of ionizing radiation a person has received over a specific period, often throughout their lifetime or during a series of medical procedures. It is typically measured in millisieverts (mSv).

Why is it important?

Increased Risk: Higher cumulative exposure can raise the long-term risk of radiation-induced effects, such as cancer.

Clinical Decisions: Helps healthcare providers evaluate whether repeated CT scans, X-rays, or nuclear medicine studies are truly necessary.

Patient Safety: Supports better radiation safety practices, especially in vulnerable populations like children or those with chronic conditions.

Tracking Exposure: Useful in occupational health for professionals exposed to radiation (e.g., radiologists, interventional surgeons).

Examples in Clinical Context

A patient undergoing multiple CT scans for cancer follow-up might accumulate over 50 mSv in a few years.

A radiation dose monitoring system can track and alert when cumulative exposure crosses certain thresholds.

Radiation exposure is a measure of the ionization of air due to ionizing radiation from photons; that is, gamma rays and X-rays.

It is defined as the electric charge freed by such radiation in a specified volume of air divided by the mass of that air.

The SI unit of exposure is the coulomb per kilogram (C/kg), which has largely replaced the roentgen (R).

One 1 roentgen equals 0.000258 C/kg; an exposure of one coulomb per kilogram is equivalent to 3876 roentgens.

As a measure of radiation damage exposure has been superseded by the concept of absorbed dose which takes into account the absorption characteristic of the target material.

Small amounts of radiation over a long time, raises the risk of cancer. It can also cause mutations in your genes, which you could pass on to any children you have after the exposure. A lot of radiation over a short period, such as from a radiation emergency, can cause burns or radiation sickness.

The potential for radiation exposure during neurosurgical training has dramatically increased in the last decade. Incorporation of instrumented and minimally invasive spinal surgery and neuroendovascular procedures into the curriculum has led to increased potential for exposure to ionizing radiation.

The study of Zaidi et al.is the first to quantify the radiation exposure for neurosurgery residents in the current era of training. From this work, efforts may be initiated to increase awareness and safety with regard to radiation exposure. Although the total dose is not high, a better understanding of the impact of radiation exposure to practitioners may help to drive institutional policies to reduce occupational exposure [1)].

Symptoms

Symptoms of radiation sickness include nausea, weakness, hair loss, skin burns and reduced organ function. If the exposure is large enough, it can cause premature aging or even death. You may be able to take medicine to reduce the radioactive material in your body.

Body habitus of the patients has a substantial impact on radiation emission during Minimally Invasive Spine Surgery MISS. Severe obesity (BMI ≥ 35) is associated with a significantly greater risk of radiation exposure compared with other weight categories. Surgical experience seems to be associated with lower radiation emission especially in cases in which patients have a higher BMI; however, further studies should be performed to examine this effect [2)].

Prevention

Preventing radiation exposure is crucial for the safety and well-being of both patients and healthcare professionals. Here are some key measures and practices aimed at minimizing radiation exposure:

ALARA Principle: ALARA stands for “As Low As Reasonably Achievable.” This principle emphasizes the importance of minimizing radiation exposure to the lowest possible level while still obtaining the necessary diagnostic or therapeutic information. Healthcare providers should adopt practices and technologies that help achieve this goal.

Time: Reducing the duration of exposure to radiation is essential. Medical personnel should strive to keep exposure time as short as possible during procedures involving radiation, such as fluoroscopy or radiography. Efficient coordination, planning, and communication among the team members can help minimize unnecessary exposure time.

Distance: Increasing the distance between the radiation source and individuals can significantly reduce exposure. Healthcare professionals should maintain a safe distance from the radiation source while still being able to perform their duties effectively. Shielding, such as lead aprons, lead gloves, thyroid collars, and leaded glasses, can also be used to protect against radiation.

Shielding: Implementing proper shielding measures is crucial for radiation safety. Radiology and interventional suites should have adequate lead-lined walls, doors, and barriers to prevent radiation leakage. Shielding materials effectively absorb and block radiation, protecting individuals in the surrounding area.

Personal Protective Equipment (PPE): Healthcare professionals involved in procedures that involve radiation should wear appropriate personal protective equipment, such as lead aprons, thyroid collars, lead gloves, and protective eyewear. PPE acts as a physical barrier between the individual and radiation, reducing exposure.

Training and Education: Healthcare professionals should receive proper training on radiation safety, including understanding the risks associated with radiation exposure, the proper use of radiation equipment, and the implementation of safety measures. Ongoing education and training programs ensure that healthcare providers stay updated on the latest guidelines and best practices.

Quality Assurance and Equipment Maintenance: Regular quality assurance checks and maintenance of radiation-emitting equipment are crucial. Routine inspections, calibrations, and performance evaluations help ensure that the equipment is functioning optimally and emitting the correct amount of radiation. Faulty or malfunctioning equipment should be promptly repaired or replaced.

Justification and Optimization: Medical professionals should adhere to the principles of justification and optimization when using radiation. Justification involves carefully evaluating the risks and benefits of radiation procedures, ensuring that the benefits outweigh the potential risks. Optimization focuses on using the lowest radiation dose necessary to achieve the desired diagnostic or therapeutic outcome.

By implementing these radiation exposure prevention strategies, healthcare professionals can effectively minimize radiation risks and maintain a safe environment for patients and themselves. It is important to follow local regulations, guidelines, and best practices specific to the healthcare facility and the type of radiation-emitting procedures being performed.

Radiation exposure prevention in spine surgery

- Computer tomography-assisted 3-dimensional navigation in spine surgery: a narrative review on safety, accuracy, efficacy and reduction of complications
- Efficacy and Safety of Donut-Shaped Circumferential Spine CyberKnife Stereotactic Body Radiotherapy for Metastatic Spine Disease
- Technical Modification of Cervical Facet Joint Radiofrequency Ablation: A Novel Approach
- Radiation Shielding Effect of Surgical Loupes Compared with Lead-Lined Glasses and Plastic Face Shields
- Reducing radiation exposure in pediatric cervical spine imaging for trauma: a multi-disciplinary quality improvement initiative
- Lateral Lumbar Interbody Fusion(XLIF & OLIF):Indications, X-ray Fluoroscopy-guided and 3D-CT Spinal Navigation Techniques, and Safe Surgical Practices to Prevent Complications
- Radiation Myelitis Risk After Hypofractionated Spine Stereotactic Body Radiation Therapy
- Augmenting Endoscopic Transforaminal Spinal Decompression Surgery (Full Endoscopic Spine Surgery) Using Stimulated Electromyography Neuromonitoring Dilators

Radiation exposure prevention is a critical consideration in spine surgery, as fluoroscopy is commonly used to guide instrument placement and ensure accurate surgical outcomes. Here are some measures to minimize radiation exposure in spine surgery:

Proper Training: Surgeons and the surgical team should receive comprehensive training on radiation safety and the proper use of fluoroscopy equipment. This includes understanding the principles of radiation protection, optimizing imaging parameters, and using shielding devices effectively.

Optimization of Imaging Parameters: Adjusting the imaging parameters of the fluoroscopy system can help reduce radiation exposure while maintaining image quality. This includes selecting appropriate pulse rates, minimizing the frame rate, and optimizing the dose settings based on the specific procedure and patient's body habitus.

Collimation and Beam Limitation: Proper collimation involves restricting the radiation beam to the smallest possible area of interest. Surgeons should ensure that the fluoroscopic beam is focused only on the specific region of the spine being operated on, rather than unnecessarily exposing surrounding areas.

Pulse Mode and Last Image Hold: Using pulse mode instead of continuous fluoroscopy can significantly reduce radiation exposure. The pulse mode allows for intermittent radiation exposure, activating the fluoroscopy beam only when necessary. Last image hold feature can be used to freeze the image and review it without continuous exposure.

Distance and Shielding: Maintaining a safe distance from the radiation source helps reduce exposure. Surgeons and operating room personnel should stand as far away from the fluoroscopy unit as possible while still maintaining clear visualization. Additionally, lead aprons, thyroid collars, lead gloves, and protective eyewear should be worn by all personnel in the operating room to shield against scattered radiation.

Image-Guided Navigation Systems: Utilizing image-guided navigation systems, such as spinal navigation, can minimize the need for fluoroscopy during certain aspects of spine surgery. These systems use preoperative imaging data to provide real-time guidance and visualization, reducing radiation exposure to both the patient and surgical staff.

Equipment Maintenance and Quality Assurance: Regular maintenance and calibration of fluoroscopy equipment are essential to ensure optimal performance and accurate dose delivery. Periodic quality assurance checks should be conducted to verify that the equipment is functioning properly and emitting the appropriate radiation levels.

Radiation Monitoring: Monitoring the radiation exposure of surgical staff is crucial. Personal dosimeters should be worn by all individuals present in the operating room to measure their radiation exposure. Regular monitoring allows for tracking cumulative doses and implementing corrective measures if necessary.

By implementing these radiation exposure prevention strategies, surgeons and healthcare professionals can significantly reduce radiation risks associated with spine surgery. Adhering to guidelines and best practices specific to the facility and following regulatory requirements ensures a safe surgical environment for both patients and the surgical team.

Three-dimensional imaging-based spinal navigation can easily be incorporated in clinical routine and serves as a reliable tool to achieve precise implant placement in lateral instrumentation of the spine. It helps to minimize radiation exposure to the surgical staff [3)]

Single-centre retrospective observational studies

Consecutive adult patients admitted to the ICU for management of aSAH over five years. Organ and effective radiation doses were determined using institution-specific conversion coefficients based on scanner radiation output metrics for all computed tomography imaging and fluoroscopy examinations. Calculated patient doses for the duration of the hospital admission were determined using National Cancer Institute radiation dosimetry tools.

A total of 276 patients met the inclusion criteria; 180 females (65%), mean (SD) age 56 (13) years. There were 222 (80%) patients who survived to hospital discharge. The median [IQR] effective cumulative radiation dose was 17.7 [9.7-30.5] mSv. Twenty-one patients (8%) received an effective dose > 50 mSv, consistent with potentially harmful ionising radiation exposure. In 162 patients (59%), the equivalent radiation dose to the lens of the eye exceeded the 500 mSv threshold for radiation-induced damage.

Survivors of aSAH are exposed to high levels of medical radiation. The eyes are particularly at risk, with most patients exposed to levels that induce lens damage. This highlights the importance of strategies to reduce incidental and cumulative medical radiation exposure in this population [4)]

This study provides a timely and important quantification of the cumulative radiation burden in patients with aSAH, particularly highlighting the vulnerability of ocular structures. It raises awareness among neurocritical care and neuroradiology teams and calls for targeted strategies to reduce unnecessary radiation. However, its retrospective design, single-centred scope, and lack of clinical outcome correlation limit its impact as a stand-alone piece of evidence.

1)
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