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Fluoroscopy:
Operation and Safety of Fixed Fluoroscopy Units

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Fluoroscopy: Operation and Safety Of Fixed Fluoroscopy Units

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Advances in technology and clinical treatment methods have led to a rise in fluoroscopy use. Coinciding with this trend is an increase in reported radiation-induced injuries from fluoroscopy. Operators of fluoroscopy units, including radiologic technologists, radiologist assistants, radiologists and other physicians, must have a thorough understanding of how imaging chain components and radiation safety features optimize diagnostic imaging quality and keep radiation exposure to as low as reasonably achievable (ALARA). This knowledge is especially important as new equipment features become available.

After completing this article, readers should be able to:

- List the components of fixed fluoroscopy units and describe different available configurations.
- Understand the importance of the as low as reasonably achievable (ALARA) principle and how to use radiation protection features available on fluoroscopy units.
- Discuss the role of fluoroscopy in imaging and interventional procedures.
- Recognize ways to improve fluoroscopic imaging of pediatric patients and keep radiation dose to a minimum.

Fluoroscopy is used most frequently to provide real-time, dynamic imaging of anatomic structures, such as circulatory movement or the motion of hollow internal structures.[1] Today, it is being used for an increasingly wide variety of procedures in diagnostic and interventional radiology.[2,3]

There are 2 basic types of fluoroscopy units, fixed and mobile, each with a multitude of designs. Fixed fluoroscopy units can be found in designated rooms of hospitals, outpatient clinics and imaging centers and may be combination radiography/fluoroscopy (R/F) or C-arm equipment.[4] Mobile units are smaller, C-arm versions of the fixed units, and as the name indicates, they can be moved as needed.[1] Fixed-imaging systems offer several advantages over mobile units, especially for advanced procedures such as endovascular surgery.[5] According to Sternbergh et al, some of these benefits include better image quality, larger image intensifiers that allow a greater field of view, reduced radiation exposure, improved postprocessing capabilities and the lack of susceptibility to overheating and shutdown during lengthy cases.[5] Both types of units require proper training in fluoroscopic procedures and protection of patients and medical personnel from unnecessary radiation exposure.[1]

Radiologist assistants (RAs) and radiologic technologists may operate fluoroscopy equipment, but the physician performing the examination or interventional procedure often operates the unit. In training hospitals and imaging clinics, it is crucial that experienced fluoroscopy operators share their expertise with others whose knowledge of radiation safety and methods of exposure control may not always be thorough or current.[4] Continuing education concerning new uses and developments in safety features is important for the protection of both patients and personnel.

Radiation Effects

Since the invention of the fluoroscope in 1896, many devices and techniques have been developed to reduce occupational and patient radiation exposure during fluoroscopy.[6] With a growing trend in prolonged fluoroscopy-guided interventional procedures, however, there has been an increase in reports of high skin doses, which can damage skin significanly.[2] The U.S. Food and Drug Administration (FDA) has compiled nearly 100 documented cases of radiation-induced burns and at least 15 cases have been confirmed by European investigations.[3]

Stochastic radiation effects are considered chronic effects and are caused by longer exposure at relatively lower doses.[7] The severity of the effect is not related to the amount of the dose but rather to the probability a radiation-induced cancer or leukemia will occur with exposure.[7] The increased risk of cancer development also depends on the age and sex of the individual at exposure; children are much more sensitive to radiation than adults.[8] It may take between 5 and 25 years for radiation-induced cancer or leukemia to appear.[7]

Deterministic effects are considered acute effects, and their severity increases with the amount of radiation received. Some examples include desquamation and damage to the connective tissues, blood vessels or glands.[7] In 2000 the International Commission on Radiological Protection (ICRP) reported the threshold dose for early transient skin burns (erythema) to be 2 Gy, with an onset between 2 and 24 hours; the threshold dose for temporary or permanent hair loss (epilation) was reported to be 7 Gy, with a 3-week onset. At 1 to 2 Gy, the lens of the eye may develop a detectable opacity or debilitating cataract within 5 years or more.[8]

Radiation dermatitis is a potential complication of fluoroscopic procedures and may be classified as acute, chronic or subacute. Acute dermatitis is caused by a dose of 2 to 8 Gy and presents as waves of erythema that may be accompanied by edema, vesiculation, erosion, ulceration or pain. It takes several weeks to several months for the condition to improve, and in some cases, the skin never returns to normal.[9]

Chronic radiation dermatitis appears several months to years after exposure and results from a cumulative dose of 10 Gy. This type of radiation dermatitis presents as telangiectasia, hair loss, erythema and pigmentary changes. The subacute form demonstrates a combination of the acute and chronic symptoms.[9]

The most common locations of fluoroscopy-associated radiation dermatitis following cardiac procedures are the scapular and subscapular areas, the right lateral trunk below the axilla, the midback and the right anterolateral chest. Patients at greatest risk for these types of injuries are those who have undergone multiple procedures, a prolonged procedure or a percutaneous coronary intervention. There is no specific treatment for patients with subacute or chronic radiation dermatitis, and they are at an increased risk for basal and squamous cell carcinomas.[9]

A follow-up visit should be scheduled 30 days after an interventional fluoroscopy procedure for any patient who receives a radiation skin dose of 2 Gy or more or a cumulative dose of 3 Gy or more. A description of the procedure, operative notes, doses and information about possible short-term and long-term effects should be sent to the patient's primary care provider, along with instructions to notify the fluoroscopy operator if skin effects are observed.[8]

Radiology-related adverse events may occur any time ionizing radiation is used for patient care. If a fluoroscopy unit is involved, the unit should not be turned off or unplugged until all data have been recorded, printed or saved in digital memory. If it is possible that equipment failure caused the adverse event, then the fluoroscopy unit should be impounded for later inspection by authorized personnel or the manufacturer. The goals of an adverse event protocol should be to:

- Alleviate suffering.
- Protect evidence.
- Document what occurred.
- Report the incident to the appropriate parties.
- Analyze the cause of the event.[10]

Fluoroscopy Overview

Fluoroscopy units can be found in many different configurations. The parts of the imaging chain are fairly consistent among fluoroscopy systems, although the system control panel varies from unit to unit. Additional components are available for digital image recording or interventional applications. Some fluoroscopy units have very-high dose rate modes that are used to generate high-quality images, but such images are not often required for simple fluoroscopy studies. It is crucial that operators understand how to manipulate the controls to produce acceptable image quality at the lowest possible dose levels. The manufacturer's application specialists should instruct fluoroscopy staff before new equipment is used to examine patients.[3]