X-Ray Imaging Physics for Nuclear Medicine Technologists. Part 2: X-Ray Interactions and Image Formation

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Abstract

The purpose is to review in a 4-part series: (i) the basic principles of x-ray production, (ii) x-ray interactions and data capture/conversion, (iii) acquisition/creation of the CT image, and (iv) operational details of a modern multislice CT scanner integrated with a PET scanner. In part 1, the production and characteristics of x-rays were reviewed. In this article, the principles of x-ray interactions and image formation are discussed, in preparation for a general review of CT (part 3) and a more detailed investigation of PET/CT scanners in part 4.

Keywords

x-ray interactions, γ-ray interactions, attenuation, x-ray image formation, x-ray detection, screen-film x-ray detectors, digital x-ray detectors, CT

Nuclear medicine imaging has been an integral component of the diagnostic radiology armamentarium for several decades and is undergoing a renaissance of importance as the world of molecular imaging and genomics becomes the current research topic of interest. As those involved in nuclear diagnostic medicine have always known, the nature of nuclear medicine has been and will continue to be molecular and provide metabolic and physiologic information as well. X-ray wavelengths are shorter than those of UV rays and typically longer than those of gamma rays. The distinction between X-rays and gamma rays is not so simple and has changed in recent decades. According to the currently valid definition, X-rays are emitted by electrons outside the nucleus, while gamma rays are emitted by the nucleus. Although a large number of possible interactions are known, there are three key interaction mechanisms with matter. The strength of these interactions depends on the energy of the X-rays and the elemental composition of the material, but not much on chemical properties, since the X-ray photon energy is much higher than chemical binding energies. A basic understanding of x-ray imaging physics is important for the nuclear medicine technologist; the goal of this series of papers is to provide this information. This article reviews the topic of x-ray production and control of the x-ray beam quality and quantity through the use of x-ray tubes, x-ray generators, and beam-shaping devices. Part 2 of this series investigates the characteristics of x-ray interactions, the formation of the projection image, image contrast, signal-to-noise ratio, and radiation dose. Part 2: X-ray interactions and image formation. J Nucl Med Technol. 2005 Mar;33(1):3-18. In this article, the principles of x-ray interactions and image formation are discussed, in preparation for a general review of CT (part 3) and a more detailed investigation of PET/CT scanners in part 4. Publication types. Review. MeSH terms. Nuclear Medicine / education. Nuclear Medicine / methods*. Positron-Emission Tomography / methods*. Radiography / methods*. 10 Cardiac Functional Imaging All major imaging modalities are working on the heart—CT: Fast multislice cardiac CT –Cardiac MRI –Echocardiography –SPECT: Cardiac perfusion imaging –PET: Cardiac viability and perfusion. 11 Cardiac Perfusion Imaging Measurement of blood flow to cardiac tissue via coronary arteries Coronary arteries may be blocked by plaques Stress versus rest studies may reveal a difference SPECT is cheap and has long been used for this purpose—Several agents, mostly 201 Tl (older) and 99m Tc. PHYSICS IN NUCLEAR MEDICINE: QUANTITATIVE SPECT AND CLINICAL APPLICATIONS Kathy Willowson Department of Nuclear Medicine, Royal North Shore Hospital University. Medical Imaging. X-Rays What is a Routine X-Ray?