X-rays imaging

The development of X-ray imaging techniques has historically been motivated by their use in the medical setting; photographic film was being used to detect X-rays as early as 1895. The advent of mass digital storage has produced alternatives and electronic detection is displacing the traditional information storage medium. Medical X-rays have increased our ability to detect injury or disease quickly and make more accurate diagnoses such that enable medical professionals to greatly improve the health of their patients.

Plain X-ray radiography

X-ray radiography remains one of the most widely used types of imaging used for medical purposes. It provides images of a good resolution and requires little preparation and examination time with the patient.

How does it work?

An X-ray generator transmits a beam of X-rays through an object (the body part to be examined), and parts of the energy of the beam are absorbed in various amounts depending on the composition of the material they pass through. A detector (photographic film) captures the attenuated X-rays on the opposite side. The degree of transmission of X-rays is recorded as a shadowgraph. Attenuation of X-ray photons depends on the photon energy (as different interaction processes dominate at different photon energies) and the atomic number of the elements present in the imaged materials (attenuation is stronger for higher effective atomic number). Bone and calcium-dense tissues have high densities and absorb X-rays very well, whilst lower-density soft tissues (including muscle fibres) behave less so. This produces the characteristic black-and-white contrast observed in X-ray images. Radiographers are able to select the type and intensity of X-rays to be used depending on the tissue or area of the body under examination and amount of contrast necessary. The X-ray image is stored as a radiograph on photographic film. Physicians can interpret these images and use them to produce a medical diagnosis. Conventional X-rays are well suited, for instance, to dental imaging and within trauma and orthopaedic departments to detect bone fractures.

Enhancing contrast

X-rays are only weakly absorbed by photographic film, so intensifier screens (thin sheets containing phosphor) are used to further blacken the screen and at the same time reduce a patient’s exposure to ionising radiation. Contrast is also improved by means of media including iodine and barium which facilitate differentiation between materials that absorb X-rays to a similar degree (such as soft tissues). Contrast media absorb X-rays well, and it follows that the tissues into which they are inserted do the same. As a result, these tissues are more clearly visible on the final X-ray image.

Digital X-ray radiography

The use of X-ray film has traditionally dominated medical imaging, being easy to use, readily available and permanent. Photographic film, however, consumes physical space, and time is required for processing images. Digital x-ray radiography utilises an electronic detector and stores information on a computer, eliminating the need for processing and providing immediate access to clinicians. In the operating theatre environment, for example, surgeons fixating fractures request X-rays during procedures, instantaneously displayed on a computer screen and progressively overwritten. This enables only the smallest necessary incisions to be made, minimising the risk of infection the patient is exposed to both during and after the procedure. Image intensifiers are also used in digital systems and are particularly useful in fluoroscopy, which involves real-time continuous screening of the patient. Here, use of an intensifier helps limit radiation exposure to both patient and medical staff.

Alternative techniques

Various X-ray imaging techniques are utilised in many medical examinations and procedures. Common methods include fluoroscopy, mammography (images internal structure of breast), angiography (uses a contrast agent to image the circulatory system) and computed tomography (produces high-resolution cross-sectional images of the body).

Adverse effects of X-ray medical imaging

X-ray has some potential to harm living tissue. At extremely high levels of radiation exposure, there is the possibility a person could sustain skin burns. More generally, in the scope of medical imaging, there is a small increase in risk that an exposed individual could develop cancer later in life. This depends on the dose of radiation (larger dose and frequent exposure increases risk), age at exposure (younger age, higher risk) and the sex of the individual (women are at a higher lifetime risk of developing radiation-associated cancer). Different tissues have a varying sensitivity to ionising radiation; therefore risk from X-ray exposure varies depending on the area under examination. Radiographers and doctors ensure the lowest possible dose is used in order to minimise the overall “effective dose” of radiation received by the patient. The risks are small enough, however, that the benefits of accurate diagnosis and treatment are considered to outweigh them.

Links

Related articles

External links

Bibliography

Chadha, G. and Sang, D., Physics for OCR (2009, Cambridge University Press, Cambridge UK), p.226-234
Franklin et al., Introduction to Biological Physics for the Health and Life Sciences (2011, John Wiley and Sons Ltd, Chichester UK), p.402
Pople, S. and Tear, C., Physics Through Diagrams (2009, Oxford University Press, Oxford UK), p.133
Vítek, F., Lectures on Biophysics with Medical Orientation (2008, The Karolinum Press, Prague), p.106-111
http://www.medicalradiation.com/types-of-medical-imaging/imaging-using-x-rays/
http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/MedicalImaging/MedicalX-Rays/default.htm